National Spatial Data Infrastructure

NSDI FRAMEWORK TRANSPORTATION IDENTIFICATION STANDARD -- *WORKING DRAFT*

Ground Transportation Subcommittee
Federal Geographic Data Committee

May , 1999

Federal Geographic Data Committee

Established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data.

The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, Interior, Justice, State, and Transportation; the Environmental Protection Agency; the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space Administration; the National Archives and Records Administration; the National Science Foundation; and the Tennessee Valley Authority. Additional Federal agencies and non-Federal agencies participate on FGDC subcommittees and working groups. The Department of the Interior chairs the committee.

FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees establish and implement standards for data content, quality, and transfer; encourage the exchange of information and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working groups are established for issues that transcend data categories.

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The following is the recommended bibliographic citation for this publication:
Federal Geographic Data Committee (Ground Transportation Subcommittee): NSDI Framework Transportation Identification Standard (Working Draft).   Washington, D.C. **,** 1999.

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1   1   **INTRODUCTION**

2   1.1 Preface

3   1.1.1   Background

4   There is considerable confusion within both the transportation and GIS communities on

5   the relationships among transportation features such as roads, their representation as geo-

6   spatial objects in geographic information systems (GIS), and their representation in

7   analytical networks. Much of this confusion results from the inconsistent use of

8   terminology to describe transportation features and their representations. It is also

9   perpetuated by current versions of GIS software, which fail to adequately address the

10   differences between lines used for cartographic displays and those used for network

11   analysis.

12   1.1.2   Need for Standards

13   One consequence of this confusion has been an inability to promulgate national standards

14   for transportation spatial features to facilitate data sharing under the **National Spatial**

15   **Data Infrastructure (NSDI)** initiative. A fundamental requirement of spatial data

16   sharing is that both the supplier and the recipient of the data understand what the data

17   represents in terms of real-world features. This is relatively straightforward for features

18   having well defined boundaries such a building or airport. However, many transportation

19   features are characterized by extensive linear networks, with no universally agreed upon

20   standard for partitioning these networks into unique "segments." Each developer of a

21   transportation network spatial database partitions the network to meet his or her specific

22   application needs.

23   1.1.3   FGDC Action

24   The **Federal Geographic Data Committee (FGDC)** was established by the Office of

25   Management and Budget (OMB) under Circular A-16 to promote the coordinated

26   development, use, sharing, and dissemination of geographic data. The committee, which

27   is composed of representatives from 16 departments and independent agencies, oversees

28   and provides policy guidance for agency efforts to coordinate geographic data activities.

29   The FGDC created the **Ground Transportation Subcommittee** in January 1992 to

30   address data issues involving transportation features and networks. The objectives of the

31   Subcommittee are to:

32   --   promote standards of accuracy and currency in ground transportation data which is

33   financed in whole or in part by Federal funds;

34   --   exchange information on technological improvements for collecting ground

35   transportation data;

36   --   encourage the Federal and non-Federal community to identify and adopt standards

37   and specifications for ground transportation data; and

38   --   promote the sharing of ground transportation data among Federal and non-Federal

39   organizations.

40   1.1.4   The NSDI Framework Transportation Framework Layer

41   Transportation is one of the seven Framework layers identified in the National Spatial

42   Data Infrastructure (NSDI). NSDI framework data represents the "best" available geo-

43   spatial data for an area. The data is collected or compiled to a known level of spatial

44   accuracy and currency, documented in accordance with established metadata standards,

45   and made available for dissemination at little or no cost and free of restrictions on use.

46   Framework data is not necessarily uniform from one area to another; the quality of the

47   data for a given area depends on the requirements of the participating data developers.

48   The NSDI does not specify threshold standards for spatial accuracy, attribution,

49   completeness of coverage, or currency for any of its framework themes. The resulting

50   framework will be a "patchwork quilt" consisting of high quality geo-spatial data for

51   some geographic areas, with lower quality or even missing data for other areas. As more

52   data developers upgrade their geo-spatial data and participate in the NSDI, the overall

53   quality of the data comprising the NSDI Framework and the completeness of nationwide

54   coverage will improve. For further information see the FGDC publication "NSDI

55   Framework Introduction and Guide,"

56   http://www.fgdc.gov/framework/frameworkintroguide/ .

57   1.1.5   The Transportation Framework

58   The importance of geo-spatial data depicting transportation features – especially road

59   networks – extends well beyond their cartographic value. Road networks provide the

60   basis for several indirect location referencing systems, including street addresses and

61   various linear referencing methods commonly used to locate features like bridges, signs,

62   pavement conditions, and traffic incidents. Geo-spatial transportation segments can be

63   connected to form topological networks, which can be used to more accurately measure

64   over-the-road travel distances between geographic locations. Furthermore, when

65   combined with the variety of network analysis tools that are available, topological

66   networks can be used to find the shortest paths between two or more locations, to

67   determine the most efficient route to cover all transportation segments (e.g., for planning

68   of snow removal), or to estimate traffic volumes by assigning origin-to-destination flows

69   to network segments.

70   Integration of the "best available" transportation databases into a national framework

71   layer must provide for nationwide connectivity in order to support the network

72   applications described above. This means that there can be no "gaps" (geographic areas

73   where transportation data is totally absent). Further, the transportation data for each

74   particular geographic area must be produced so that it can be connected topologically to

75   transportation data for adjacent areas.

76   1.1.6   Federal, State and Local Transportation Data Resources

77   A nationwide NSDI framework road layer *could* be constructed from the national level

78   databases developed by federal agencies: **Bureau of the Census** TIGER/Line files, **U.S.**

79   **Geological Survey** Digital Line Graph (USGS/DLG) files, and the National Highway

80   Planning Network (NHPN) developed by the **Federal Highway Administration**

81   (FHWA). These databases serve most federal needs and many general public

82   requirements for national level road data at the 1:100,000 scale, and provide network

83   connectivity in those areas where more accurate transportation data does not exist.

84   However, such a database would not offer the currency, completeness, and accuracy

85   required by many other users.

86   Over half of the state Departments of Transportation (DOTs) have developed road

87   databases at a scale of 1:24,000 or better. These databases are almost certainly of

88   superior accuracy, completeness and currency than the national databases, and *could* take

89   the place of federal road data as the framework database for their respective areas,

90   providing they meet other NSDI framework requirements (e.g., metadata documentation,

91   no restrictions on use). Road data which is even more accurate and current exists for

92 many smaller geographic units; e.g. counties or metropolitan areas. These databases

93 *could* be utilized instead of either the federal or state transportation data as the framework

94 database for their specific areas.

95 1.1.7   The Challenge

96 Creation of the NSDI framework transportation layer will require the participation of a

97 large number of federal, state, and local transportation agencies, and their contribution of

98 transportation databases developed for specific geographic areas and applications. The

99 databases will be – or have been – developed at different scales, with different levels of

100 positional accuracy, detail and completeness of coverage, and currency. These databases

101 will have to be "stitched together" in order to provide the network connectivity required

102 for many transportation applications. When new databases are added to the framework,

103 or when specific attributes are updated or enhanced, users of framework data will need to

104 be able to incorporate this new information into their applications in ways that are cost-

105 effective.

106 The process of transferring information (including more accurate coordinates) from one

107 geo-spatial database to another is known as "conflation." Successful conflation requires

108 that the features in one geo-spatial database be matched to their counterparts in the other

109 database. Once this match is achieved, geometric and/or attribute data can be exchanged

110 from either of the two databases to the other. For example, coordinate data depicting the

111   alignment of a transportation segment can be transferred from a transportation database

112   digitized from 1:12,000 scale digital orthophotoquads (DOQs) to a database that had

113   originally been digitized from 1:24,000 scale USGS topographic maps.

114   Typically the process of conflation uses a combination of coordinate matching and name

115   matching. Depending on the similarity of the two databases, the percentage of

116   successfully matched features can vary from over 90 percent to well under 50 percent.

117   This range of variability is unacceptable for successful implementation of the NSDI

118   framework, which will require ongoing additions of new framework databases and

119   transactional updates to attributes in existing framework databases.

120   A more promising conflation method starts with the assignment of a stable and unique

121   identifier to each geo-spatial feature. This identifier can then be used to match features

122   across databases without having to rely on coordinate accuracy or the use of standard

123   names. Unique feature identifiers work best when instances of features are well defined

124   and spatially distinct.

125   The identification of a discreet feature instance is not always obvious for linear features

126   such as roads and surface waters. Roads are segmented in an almost infinite number of

127   ways, depending on the application needs of the database developer. Roads may be

128   segmented at intersections for path building, or at changes in one or more attributes for

129   use in facility management. Also, a transportation segment may terminate at a state,

130   county, or municipal border, or other jurisdictional boundary.

131   Within the same geographical area multiple entities may create, update, and/or use

132   different transportation databases. For example, a state DOT may create a transportation

133   database that includes only state highways, and may segment its roads wherever one

134   highway intersects another. A local transportation planning agency might create a

135   database for the same area that includes all local roads; this agency could segment the

136   state highways wherever they intersect any road. Finally, an E-911 agency could create

137   yet a third transportation database for the area, segmenting all roads at each private

138   driveway.

139   Most geographic information system (GIS) software packages currently do not enable the

140   user to distinguish between an instance of a linear geo-spatial feature and how that feature

141   is represented in a topological network. Each of the transportation databases mentioned

142   above represents the same physical transportation network but divides it into different –

143   often overlapping – segments in order to establish topological connections needed for the

144   respective applications. Each segment becomes a distinct record in the geo-spatial

145   database unique to that application. Finding a set of common transportation segments

146   that carry topology and are useful in all existing and potential applications is impossible

147   in most geographic areas.

148   The concept of a permanent transportation segment identifier is attractive, but the need to

149   add new transportation segments to accommodate other applications or to reflect changes

150   in infrastructure creates a topology maintenance nightmare. Consider the case of a road

151   segment (Segment_A) with an assigned permanent identifier (illustrated in Figure 1). A

152   new road (Segment_B) is built

153   which intersects the old road

154   segment part way along its length.

155   In order to maintain network

156   topology, the old road segment

157   must be split and a node

158   established where the new road

159   intersects. The identifier for the
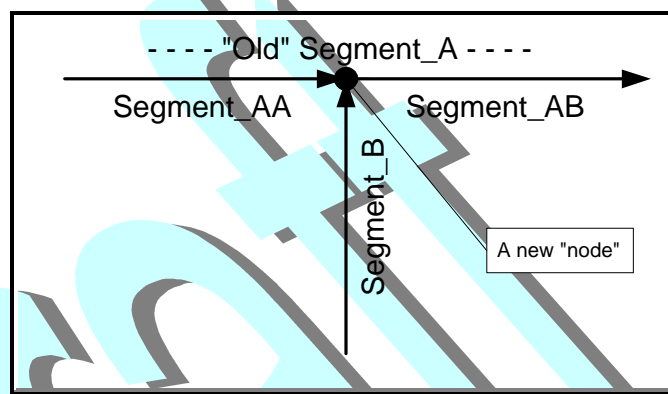
Figure 1 - Intersecting Road Segments

160   old road segment is no longer valid. It must be retired and three new identifiers created:

161   one for the new intersecting road (Segment_B) and one for each new segment

162   (Segments_AA   and AB) of the (now split) old road segment. Recording,

163   disseminating, and applying these transactions would become prohibitively time

164   consuming, both for the database developer and for users trying to incorporate the

165   updated information into their own application database.

166   In summary, the growing needs of users make the argument for constructing an NSDI

167   framework transportation data layer(s) a compelling one. Also, all users will benefit if the

168   investments in high quality transportation information being made by many units of state

169   and local government can be incorporated. The related technical requirements present a

170   challenge in the development of standards, technology and procedures which will be

171   needed in order to accomplish this task.

172   1.2   Justification

173   1.2.1   Objective

174   The objective of this content standard is to specify methods for identifying linear geo-

175   spatial features that can be implemented within existing data structures without some of

176   the topological problems cited above. Furthermore, the proposed standard should allow

177   users to create customized topological networks from the reference segments without

178   modifying the properties of the reference segments themselves. Successful achievement

179   of this objective will facilitate transactional updates to framework transportation

180   databases by allowing new transportation features to be added without changing existing

181   transportation segments. The standard should define a transportation segment in such a

182   way that it is independent of cartographic scale, cartographic representation – irrespective

183   of scale, attributes which can change over time, and network topology. Each defined

184   transportation segment can then be assigned a unique identifier that does not need to be

185   modified for different applications or for additions of new transportation features.

186   Establishment of stable transportation segment identifiers will facilitate the exchange of

187   information between databases; e.g., improved geo-spatial coordinates, feature attributes

188   like road names, or controls to various linear referencing methods like beginning and

189   ending mile points or low and high address values.

190   The **NSDI Framework Transportation Identification Standard** defines the collection

191   of objects which serve as the basis for transferring information among different networks,

192   higher level linear referencing systems, and cartographic representations of roads. The

193   standard relates multiple cartographic and topological network data base representations

194   to uniquely identified transportation segments in the real world, and provides the domain

195   for transferring application attributes across linear referencing and cartographic systems.

196   The model consists of a set of one-dimensional **Framework Transportation Segments**

197   **(FTSeg)** that have zero-dimensional **Framework Transportation Reference Points**

198   **(FTRP)** at their termini. FTRP and FTSeg are highly stable, unambiguously identified,

199   and recoverable in the field.

200   The standard is not intended to be a geodetic or linear datum. It contains no specification

201   for either coordinate or linear measurement accuracy. However, the standard does

202   provide a structure for accommodating a linear datum by including coordinates and length

203   measures as attributes, and by requiring accuracy statements whenever such measures are

204   specified. This enables users to assess the suitability of the geometry or attributes from

205   one or more transportation databases for their particular application(s).

206   1.2.2   Scope

207   The NSDI Framework Transportation Identification Standard is being proposed as an

208   "FGDC data content standard." It includes both mandatory standards for assigning and

209   reporting identification codes as well as voluntary guidelines for data capture under the

210   classification of a process standard.

211   **Part II** of this document provides a standard for identifying physical transportation

212   segments that are temporally stable and independent of any cartographic representation,

213   scale, level of detail, or network application. The standard includes a mandatory set of

214   attributes for each Framework Transportation Segment (FTSeg), and a format for a

215   unique identification code to be assigned to each identified segment. Each FTSeg begins

216   and ends at a Framework Transportation Reference Point (FTRP); mandatory attributes

217   and an identification code for each FTRP are also specified.

218   Part II also specifies a process for assigning, modifying and recording FTRP and FTSeg

219   identification codes, and proposes a national registry for their identification. Any

220   transportation databases considered to be compatible with the NSDI transportation

221   framework layer must conform to this standard.

222   The standard articulated here can be extended in the future to cover other transportation

223   networks including railroads, commercial waterways, pipelines, and public transit guide

224   ways. Other network layers will require different process standards for assigning and

225   recording identification codes. These additional process standards are not included as

226   part of this initial standard.

227   **Part III** of this document is made up of technical appendices, including references, a

228   glossary of relevant terms, examples, and further information. It includes guidelines for

229   selecting and locating the reference points of appropriate transportation segments, as well

230   as other implementation procedures. The user of the standard does not have to follow the

231   guidelines to be in conformance with the standard.

232   1.2.3   Applicability

233   This proposed standard will have widespread applicability for public-sector and

234   commercial database developers and data users, because there are no national standards

235   for identifying, segmenting, or representing transportation segments in digital geo-spatial

236   databases. Each database developer segments transportation networks to satisfy his/her

237   specific application needs; however, the segmentation may not be appropriate for other

238   applications. Furthermore, there is no standard approach for documenting the

239   relationship between a digitized transportation segment and the physical transportation

240   feature that it represents. Consequently, the exchange of attribute information between

241   two different transportation databases representing the same geographic area is difficult,

242   time consuming and error prone.

243   The proposed national standard for identifying and documenting transportation segments

244   will facilitate data exchange among different users by providing well defined, common

245   reference segments that are tied to the physical transportation feature, rather than to any

246   cartographic or network abstraction of that feature. It will allow users to create

247   customized topological networks from the reference segments without modifying the

248   properties of the reference segments themselves, and to make transactional updates to

249   framework transportation databases.

250   1.2.4   Consistency with Other Relevant Standards & Policies

251   1.2.4.1   FGDC Standards

252   1.2.4.1.1 **Spatial Data Transfer Standard (SDTS)**

253   The purpose of the SDTS is to promote and facilitate the transfer of digital spatial data

254   between dissimilar GIS software packages, while preserving information meaning and

255   minimizing the need for information external to the transfer. Implementation of SDTS is

256   of significant interest to users and producers of digital spatial data because of the

257   potential for increased access to and sharing of spatial data, the reduction of information

258   loss in data exchange, the elimination of the duplication of data acquisition, and the

259   increase in the quality and integrity of spatial data. SDTS is neutral, modular,

260   growth-oriented, extensible, and flexible -- all characteristics of an "open systems"

261   standard.

262   The SDTS includes conceptual models and definitions for spatial objects; a partial

263   glossary of geo-spatial features; and standardized files structures and encoding

264   specifications. The SDTS accommodates all forms of spatial data representation

265   including raster, vector and graphical objects. In its general form, it is too complex to be

266   implemented within a single translation software program. Instead, more restrictive

267   SDTS profiles are being developed to transfer a specific type of spatial data. To date,

268   profiles have been developed for planar topological vector data, raster data, and high

269   precision point data. For further information see http://mcmcweb.er.usgs.gov/sdts/.

270   **1.2.4.1.2 SDTS Transportation Network Profile (TNP)**

271   A draft profile was developed in 1995 for transferring non-planar vector data,

272   characteristic of transportation networks. However, the profile was not submitted for

273   formal adoption due to a number of unresolved issues. This standard is expected to

274   address most of these issues and thereby enable resumption of the TNP development. For

275   further information see: http://www.bts.gov/gis/reference/tnp_11.html.

276   **1.2.4.1.3 Facility Identification Data Standard** (proposed by the FGDC Facilities

277   Working Group)

278   The proposed "FGDC Data Content Standard for Location and Identification of

279   Facilities" is intended to develop a Facility Identification data standard that supports

280   identification of place-based objects generally known as facilities. The draft standard

281 incorporates identification of transportation objects which are defined as "Framework

282 Transportation Segments." The proposed identifiers are defined and derived

283 inconsistently in the two drafts; the Chair of the Ground Transportation Subcommittee

284 has noted this in written comments. The Ground Transportation Subcommittee and the

285 Facilities Working Group will work together to define a consistent identifier or to

286 appropriately delineate the scope of each standard. For further information see

287 http://www.fgdc.gov/standards/status/sub3_3.html .

288 1.2.4.1.4 **Ground Transportation Data Content Standard** (proposed by the FGDC

289   Facilities Working Group)

290 The proposed "Data Content Standard" is intended to provide a common set of

291 entity/attribute/domain definitions for transportation features. The Framework

292 Transportation Identification Standard will provide the foundation on which

293 transportation features in this content standard will be defined, and these two efforts will

294 be closely coordinated. (See http://www.fgdc.gov/Standards/Status)

295 1.2.4.1.5 **Address Content Standard** (proposed by the FGDC Cultural and

296   Demographic Subcommittee)

297 The proposed "Address Content Standard" is intended to provide consistency in the

298 maintenance and exchange of address data and enhance its usability.

299   This proposed standard will provide semantic definitions for components determined by

300   the participants to be integral to the creation, maintenance, sharing, usability, and

301   exchange of addresses and/or address lists. Within this scope, addresses are broadly

302   defined as locators to places where a person or organization may reside or receive

303   communications, but excluding electronic communications. An address list consists of

304   one or more addresses. The "Address Content Standard" will additionally define an

305   entity-relationship model for address data. The "Transportation Identification Standard"

306   will establish criteria for defining and constructing transportation centerline networks to

307   which address ranges and other linear referencing methods may be appended. The

308   "Transportation Identification Standard" development is being coordinated with the

309   address content standard to ensure they are compatible.   (See

310   http://www.fgdc.gov/standards/status/sub2_4.html.)

311   1.2.4.1.6 **National Hydrography Dataset**

312   The National Hydrography Dataset project aims to produce a well-documented,

313   maintainable and nationally-consistent hydrography dataset. This database is also a non-

314   planar topological network, and many of the same concepts will be used in the

315   Transportation Identification Standard. However, the Transportation Identification

316   Standard includes certain enhancements to handle the non-dendritic properties of

317   transportation networks and to allow multiple data developers to contribute and enhance

318 transportation data for the same geographic area. For further information see

319 http://nhd.fgdc.gov.

320 1.2.4.2   Other Organizations

321 1.2.4.2.1 **Vector Product Format**

322 VPF is a standardized format, based on a geo-relational data model, developed by the

323 Defense Mapping Agency (now known as the National Imagery and Mapping Agency

324 (NIMA)), for large geographic databases. VPF is designed to be compatible with a wide

325 variety of applications and products, and allows application software to read data directly

326 from various storage media without prior conversion to an intermediate form. VPF was

327 primarily created as a storage and transfer format for cartographic data developed,

328 maintained, and used by the military. It does not address the specific requirements of

329 non-planar topological networks, nor does it address issues of data enhancement from

330 multiple contributors. Databases constructed using the Transportation Identification

331 Standard should be easily convertible to VPF.   For further information see

332 http://164.214.2.59/vpfproto/index.htm .

333 1.2.4.2.2 **Other Models and Standards: GIS-T, Intelligent Transportation Systems,**

334   **and GDF**

335   The **GIS for Transportation** (GIS-T) research community has been investigating

336   transportation data models for several years, and several candidate conceptual models

337   have been proposed. The **Intelligent Transportation Systems** (ITS) movement has also

338   addressed interoperability across data bases. For the most part, however, these candidate

339   models are unfamiliar to many of the spatial database developers who are currently

340   engaged in NSDI Framework activities.

341   This proposed standard is intended to use terminology and concepts which are entirely

342   consistent with the GIS-T work, the ITS work, and other transportation conceptual

343   models described elsewhere. At the same time the proposed standard is focused on

344   objectives which are more limited than those advanced by either of these two efforts.

345   These limitations are intended to make the proposed NSDI standard easier to understand

346   and to implement across multiple database environments. Further information relating to

347   GIS-T can be obtained at http://www2.nas.edu/trbcrp/685a.html . Further information

348   relating to ITS can be obtained at

349   http://itsdeployment.ed.ornl.gov/spatial/files/ITSDEF.htm .

350   **Geographic Data Files** format (GDF) is a European standard that is used to describe and

351   transfer road networks and road related data. GDF provides rules how to capture the data,

352   and how the features, attributes and relations are defined. GDF has been developed in a

353   European project called EDRM (European Digital Road Map). Its primary use will be for

354   car navigation systems, but it is very usable for many other transport and traffic

355   applications like Fleet Management, Dispatch Management, Traffic Analysis, Traffic

356   Management, Automatic Vehicle Locations etc.

357   GDF version 3.0 has been released and issued to CEN (Central European Normalization)

358   for the voting procedure. After the voting GDF will become the only CEN accepted

359   standard for digital road networks; ISO standardization of GDF is expected in 1999. For

360   further information see http://www.ertico.com/gdf/index.htm.

361   1.2.5   Standards Development Procedures

362   The FGDC initiated work on this proposed standard in December 1997 through a data

363   developers' workshop held to discuss the topic. Workshop participants presented

364   examples of their work on Framework projects, and articulated many common elements.

365   For further information see http://www.fgdc.gov/framework/page04.html .

366   The first draft of this standard was prepared during the summer and early fall of 1998, for

367   the review of a technical committee called together at the invitation of the Chair of the

368   FGDC Ground Transportation Subcommittee. This is a second draft version, and is

369   currently in Step 2 (Review Proposal) of the FGDC Standards Reference Model.

370   1.2.6   Maintenance Authority

371   The current maintenance authority for the standard is the Bureau of Transportation

372   Statistics (BTS) of the United States Department of Transportation (USDOT.) Questions

373   concerning the standard should be addressed to: Bruce Spear, Chairman – FGDC Ground

374   Transportation Subcommittee, c/o USDOT/BTS, 400 Seventh Street, SW Washington,

375   DC 20590. Copies of this publication are available from the FGDC Secretariat, in care

376   of the U.S. Geological Survey, 590 National Center, Reston, Virginia 20192; telephone

377   (703) 648-5514; facsimile (703) 648-5755; Internet (electronic mail)

378   fgdc@www.fgdc.gov. The text also is available at the FGDC web site

379   http://www.fgdc.gov/standards/ .

28   2   **The Framework Transportation Identification Standard**

29   2.1 Overview

30   A key piece in creating a national standard for geo-spatial data representing transportation

31   networks is the development, implementation, and general acceptance of a transportation

32   identification standard. The function of such a data standard is to enable database

33   developers to transact updates and to exchange information by defining unique and

34   relatively stable transportation segments that can be assigned a permanent feature

35   identifier.

36   2.2   Relationships between the "Real World", Cartography, and Networks, and the

37   Framework Transportation Identification Standard

38   A useful transportation identification standard must successfully address several issues

39   without causing unreasonable extra burden to either database developers or users. First,

40   the standard must be useful in representing the physical or real-world domain of

41   transportation features. Second, the standard must be useful in fulfilling the wide variety

42   of mapping requirements of users. Third, the standard must support a large number of

43   different network applications; for example: *address geo-coding, network pathfinding,*

44   *vehicle and incident location,* and *highway facility management*. Each of these

45   applications typically segments the network in different ways.

46   2.2.1   Physical ("Real-World") Domain

47   Transportation features in the physical or real-world domain consist of tangible objects

48   such as *roads, bridges, railroad tracks, and intersections*. At a minimum, representations

49   of physical objects require information to enable someone to locate and recognize them in

50   the real world. Location information may be purely descriptive (e.g. *"the intersection of*

51   *the centerlines of 7th & D Streets, SW in Washington, DC"*), <u>or</u> the description may be

52   supplemented by measurements that can be repeated in the field (e.g., GPS coordinates).

53   This Standard supports the unambiguous identification of unique real-world features by

54   requiring some descriptive information and some positional information about each

55   feature, and by allowing its augmentation with other information when users make it

56   available.

57   2.2.2   Cartographic Domain

58   Cartographic objects are used to represent real world features on a map. In vector-based

59   GIS, real-world objects are typically displayed as *points* (or *symbols*), *lines,* or *polygons*.

60   Transportation networks are displayed using points and strings of line segments. While

61   there is no *a priori* requirement that cartographic points and strings must be topologically

62   connected, most GIS software build topology to facilitate spatial and network

63   computations. However, the topology created by the GIS may not be the same as the

64   topology specified in the transportation network (e.g., a node may be placed where two

65   links cross but don't intersect).

66   Planar coordinates define the relative locations and shapes of cartographic objects on a

67   two-dimensional plane. These coordinates are typically transformations of real world

68   geographic coordinates (e.g., given a specified geodetic datum and projection). However,

69   the relative accuracy of each plotted point is subject to various errors (e.g., physical

70   location measurements, digitizing accuracy, and distortions caused by planar projections

71   of three-dimensional distances). Consequently, there are differences in both the location

72   and distance measurements between the real world and a map.

73   This Standard does not attempt to address these cartographic difficulties; nor does it

74   attempt to reconcile the differences that exist among multiple cartographic

75   representations of the same real-world features. However it does propose a standard

76   method for specifying real-world features, so that users of different cartographic

77   representations can more easily exchange updates to both geometric and tabular

78   information.

79   2.2.3   Network Domain

80   Network objects consist of *links* and *nodes,* which together form the *network*; these

81   objects are inherently topological. Transportation networks provide information on the

82   feasible paths between specified locations, and on decision points along those paths.

83   Origins and destinations are assumed to be specific as to location, but the location of a

84   decision point need not exist in the physical world (e.g., a decision point might be to

85   drive or take transit). Similarly, a network does not require cartographic coordinates,

86   only a set of choices at each decision point (e.g., the decision point to drive or take transit

87   can be made at any time or place prior to the decision to use transit).

88 This Standard does not attempt to define topological relationships within any one or more

89 networks, but does provide to the users of multiple networks a stable identifier or real-

90 world features that will not change over the time in which their network application needs

91 change.

92 2.3 Components of the Transportation Identification Standard

93 2.3.1 **Framework Transportation Segment Reference Point (FTRP)** -- *The*

94 *specified location of a (required) endpoint of a Framework Transportation*

95 *Segment (FTSeg), or an (optional) reference point offset along the length of the*

96 *FTSeg, on a physical transportation system.*

97 A FTRP database record has a unique key consisting of fields 1, 4 and 5 (emboldened);

98 Values are required for all fields, except those designated "optional" or "required when

99 applicable" (see following table.) An FTRP record contains the following information:

#	FTRP Field-Name	Description & Format/Domain
1	**FW-Transportation-Reference-Point-ID**	Permanent and unique identifier for the FTRP Format specified in Section 2.7
2	Location-Description	Unambiguous description of the FTRP that makes it field-recoverable Free text: 255 characters or less

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103	3	Category	**P** = Physical; **L** = Logical
104	**4**	**Date**	Date of creation of the record Format YYYYMMDD
105	**5**	**Authority-ID**	Permanent and unique identifier of the organization which created this record. This ID may differ from the ID of the authority which created the original FTRP database entry or subsequent records. Format specified in Section 2.7
106	6	Latitude	Angular distance measured on a meridian north or south from the equator. (NAD83) Format: +/- DD.dddddd; 10 character Decimal degrees Range: +/-0 to 90.000000
107	7	Longitude	Angular distance between the plane of a meridian east or west from the plane of the prime meridian. (NAD83) Format: +/- DDD.dddddd; 11 character Decimal degrees Range: +/-0 to 180.000000
108	8	Horizontal-Accuracy	Maximum estimated error in horizontal location Format: MMM.M; 5 character positive integer, indicating "plus or minus" a number of meters

109	9	Horizontal-Accuracy-Measurement-Method	A code which describes the derivation of the horizontal position, and which allows the user to assess the accuracy and precision of the FTRP latitude and longitude:
			100 = Derived from stationary GPS measurement, with no differential correction
			*1xx = Stationary GPS measurement -differentially corrected to "xx" meters; e.g., **105** = differential correction to 5 meter accuracy
			200 = Derived from mobile GPS measurement, without differential correction
			*2xx = Derived from mobile GPS measurement, differentially corrected to "xx" meters
			300 = Derived from non-GPS survey methods - accuracy unknown
			*3xx = Derived from non-GPS survey methods - accuracy certified to "xx" meters
			400 = Digitized from digital orthoimagery - Source scale unknown
			4xx = Digitized from digital orthoimagery - Source scale of image in 000's; e.g. 412 =1:12,000 scale source digital orthophotos.
			5xx = Digitized from paper map sources larger than 1:100,000 scale - Source scale in 000's e.g. 524 = 1:24,000 scale topographic maps
			600 = Source scale 1:100,000 digital data - e.g., TIGER/Line or DLG
			6xx = Digitized from paper map sources smaller than 1:100,000 scale - Source scale in 100,000's e.g. 625 = 1:250,000 scale maps
			900 = Other
			"xx" should be "01" when accuracy certified to 1 meter or less.

110	10	Elevation *(Optional and Recommended)*	Elevation above/below sea level Format: +/- DDDD.ddd; 9 character Decimal meters
111	11	Vertical-Accuracy-Description *(Required if Elevation is not "blank")*	Three-character code which describes the derivation of the Elevation, and which allows the user to assess the accuracy and precision of the FTRP elevation: **100** = Derived from stationary GPS measurement, differentially corrected **200** = Derived from stationary GPS measurement, without differential correction **300** = Derived from mobile GPS measurement, differentially corrected **400** = Derived from mobile GPS measurement, without differential correction **500** = Derived from ground survey measurement **600** = Derived from a Digital Elevation Model **900** = Other
112	12	FTSeg-ID *(Required when Applicable)*	Unique identifier of an FTSeg along which this FTRP falls. Format specified in Section 2.7
113	13	FTSeg-Offset-% *(Required if FTSeg-ID is not blank)*	Percentage offset from the FTSeg From-End-Point at which this FTRP falls A positive decimal number greater than or equal to "0" and less than "100". Format: 00.0000; 7 characters
114	14	Status	**P** = Proposed; **A** = Active; **R** = Retired

115   Fields emboldened above are "key" fields – **FTRP-ID, Authority** and **Date**; taken

116   together, they make up a unique key for each record. They are required so that a record

117   which describes a specific FTRP can be improved over time. Multiple authorities and

118   data users will recognize, access, use, and archive FTRP records that represent a "real

119   world" location, as identified by a particular authority and a particular point in time.

120   The textual **Location-Description** – which is also required – must be sufficient to allow

121   all users to unambiguously identify that FTRP in the field. However changes in

122   applications and technology will allow the multiple authorities to refine over time the

123   specifics of the Location-Description, coordinates, and accuracy Description. The use of

124   a multi-part key provides relative permanence to the **FTRP-ID**, while allowing the

125   creation of additional database records which can reflect these refinements. As a result,

126   users will be able to embed FTRP within their own data structures, and acquire refined

127   information about them over time (as it is made available by multiple authorities). At the

128   same time they will not have to expend resources on updating internal references to this

129   primary key.

130   Each FTRP is assigned a **Category** of P-Physical or L-Logical; points that are "logical"

131   are most often those used in small-scale representations of more complex physical

132   features. Examples of "logical" points include single-point representations of complex

133   intersections. An FTRP which is "logical" represents a point on or at the end of a FTSeg

134   over which a vehicle cannot pass while remaining within the traveled way.

135   The **Latitude** and **Longitude** of each FTRP must be provided; associated metadata fields

136   are optional. When the **Elevation** is not blank, a valid **Vertical-Accuracy-Description**

137   code is also required.

138   An **FTSeg-ID** is not required when the FTRP lies at the terminus of one or more FTSeg

139   and is not offset along the length of another FTSeg. There are three circumstances in

140   which an FTSeg-ID is required. First, the FTRP may terminate one or more FTSeg at a

141   point offset along the length of another segment. These two (or more) physically-

142   connected FTSeg are said to have an "explicit" connection at this FTRP, and this FTRP

143   record must contain this information. Second, a "free-standing" FTRP may be offset

144   along the length of an FTSeg in order to establish the distinction among two or more

145   segments which terminate at the same two endpoints. Finally, a "free-standing" FTRP

146   may be placed along an FTSeg to mark its intersection with an important but unconnected

147   linear feature (jurisdiction boundary, railroad or water bridge). When an **FTSeg-ID**

148   occurs in the record, an **FTSeg-Offset-%** is also required.

149   A required **Status** code allows authorities to design and share/compare "proposed" FTRP

150   with other interested authorities before coming to agreement on their designation. Also

151   retention of records coded as "retired" enables users to update their databases after FTRP

152   have been retired because of physical re-alignments or reconciliation of duplicate records.

153   2.3.2   **Framework Transportation Segment (FTSeg)** – *A specified directed path*

154   *between two Framework Transportation Segment Reference Points along a*

155   *physical transportation system that identifies a unique segment of that physical*

156   *system*

157   FTSeg have no explicit geometry other

158   than the locations of associated reference

159   points (FTRP). Most FTSeg terminate at

160   two FTRP. However, cul-de-sac loops
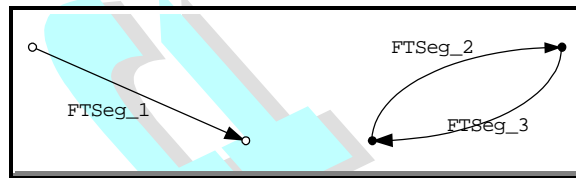
Figure 1 – Unique pathways connecting two FTRP

161   may consist of FTSeg which originate and terminate at the same FTRP, and FTSeg may

162   have other FTRP offset along their length. FTSeg should be depicted either by straight

163   lines connecting two FTRP or by curved lines (if two or more FTSeg terminate at the

164   same two FTRP.)[1] FTSeg must meet the following requirements:

165   1) FTSeg represent a physical component of the transportation network, with

166   unambiguous beginning and end points (FTRP) that can be initially located and

167   subsequently recovered in the field.

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[1]Guidelines for cartographic representation of FTRP and FTSeg are provided in Section 1.8.2 of Informative Appendix C.

168   2) FTSeg are independent of any particular cartographic display or analytical

169   network. The nodes of a particular analytical network may be useful in defining the

170   FTRP which begin and end a FTSeg, but other points may serve as well.

171   3) FTSeg are stable over time. New links are routinely added, and existing links are

172   routinely split in many transportation networks.   The new link may represent a

173   newly constructed road, or it may simply be the inclusion of a set of links (e.g.,

174   driveways) to support a particular application. In either case, it should not be

175   necessary to change the existing FTSeg to handle these additional links. In some

176   instances it may be necessary to modify a FTSeg (e.g., a road is realigned, a new

177   road is built, or a railroad track is torn up). Specific update procedures are needed to

178   handle such situations, and are detailed in Section III of this document.

179   A FTSeg database record has a unique key consisting of fields 1, 5 and 6 (emboldened);

180   all fields are required, unless otherwise indicated (see following table.). An FTSeg record

181   contains the following information:

#	FTSeg Field-Name	Description & Format/Domain
1	**FW-Transportation-Segment-ID**	Permanent and unique identifier for the FTSeg Format specified in Section 2.7
2	From-End-Point	Unique identifier of the FTRP at which this FTSeg begins Format specified in Section 2.7

182 for header row, 183 for row 1, 184 for row 2

185	3	To-End-Point	Unique identifier of the FTRP at which this FTSeg ends Format specified in Section 2.7
186	4	Path-Description	Unambiguous description of the path of this FTSeg, which is unique with respect to any other FTSeg which connects the same two End-points. Free text: 255 characters or less
187	**5**	**Date**	Date of creation of the record Form YYYYMMDD
188	**6**	**Authority-ID**	Permanent and unique identifier of the organization which created the record. This ID may differ from the ID of the authority which created the original FTSeg database entry or subsequent records. Format specified in Section 2.9
189	7	Category	**P** = Physical; **L** = Logical

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190	8	Intermediate-Point *(Required when Applicable)*	Identifier of the FTRP located at an intermediate point on the FTSeg for the purpose of distinguishing this FTSeg from (one or more) other FTSeg which share the same end points. Format specified in Section 2.7
191	9	State	Two-character code indicating the State, territory or equivalent entity within which the transportation segment begins and ends Codes are specified in FIPS 6-4
192	10	Length *(Optional and Recommended)*	Measured length of the segment Format: DDDD.ddd; 8 character Decimal meters
193	11	Length-Accuracy-Description *(Required if Length is not "blank")*	Three-character code which describes the derivation of the Length measurement, and which allows the user to assess the accuracy and precision of the FTSeg length: **100** = Measured by a transportation measurement device ("fifth wheel") **200** = Measured by an automobile odometer or analogous device **310** = Computed from a digital vector database scaled at smaller than 1:12000 **320** = Computed from a digital vector database scaled at from 1:12000 to 1:100,000 **330** = Computed from a digital vector database scaled at greater than 100,000 **900** = Other
194	12	Status	**P** = Proposed; **A** = Active; **R** = Retired

195   Fields identified as "key" fields are required in order that FTSeg records can be improved

196   by multiple authorities over time, archived, and accessed by different users, just as FTRP

197   records can be. The **From-End-Point** and **To-End-Point** values are required in order to

198   unambiguously delineate each FTSeg. (Refer to description **Intermediate-Point**, below.)

199   A textual **Path-Description** that is sufficiently complete as to allow other users to

200   unambiguously identify the course of the FTSeg in the field is also required.

201   Each FTSeg is assigned a **Category** of P - "Physical" or L - "Logical;" segments that are

202   "logical" are most often those used in small-scale representations of more complex

203   physical features. Examples of "logical" segments include single-line representations of

204   divided highways. An FTSeg which is "logical" represents a transportation segment over

205   which a vehicle cannot pass while remaining within the traveled way. An FTSeg should

206   be designated as physical ONLY if it begins and ends at a physical FTRP.

207   An FTSeg record must include a **Intermediate-Point** consisting of a single FTRP-ID

208   whenever the FTSeg in question terminates at the same two FTRP as one or more other

209   FTSeg. The additional FTRP identified in this field should represent an intermediate

210   point along the FTSeg, judiciously selected in order to assure that the multiple FTSeg

211   which terminate at the same FTRP are unambiguously differentiated.

212   A required **State** code allows authorities and users to more easily identify records of

213   possible interest. Further information can be found in FIPS Publication 6-4 at

214   http://www.itl.nist.gov/div897/pubs/fip6-4.htm .

215   **Length** and associated metadata are optional. A required **Status** code allows authorities

216   to design and share/compare "proposed" FTSeg with other interested authorities before

217   coming to agreement on their designation. Also retention of records coded as "retired"

218   enables users to update their databases after FTSeg have been retired because of physical

219   re-alignments or reconciliation of duplicate records.

220   While FTSeg have no explicit geometry themselves, they may be represented by a variety

221   of cartographic line segments depicting their shape and location on the earth. The line
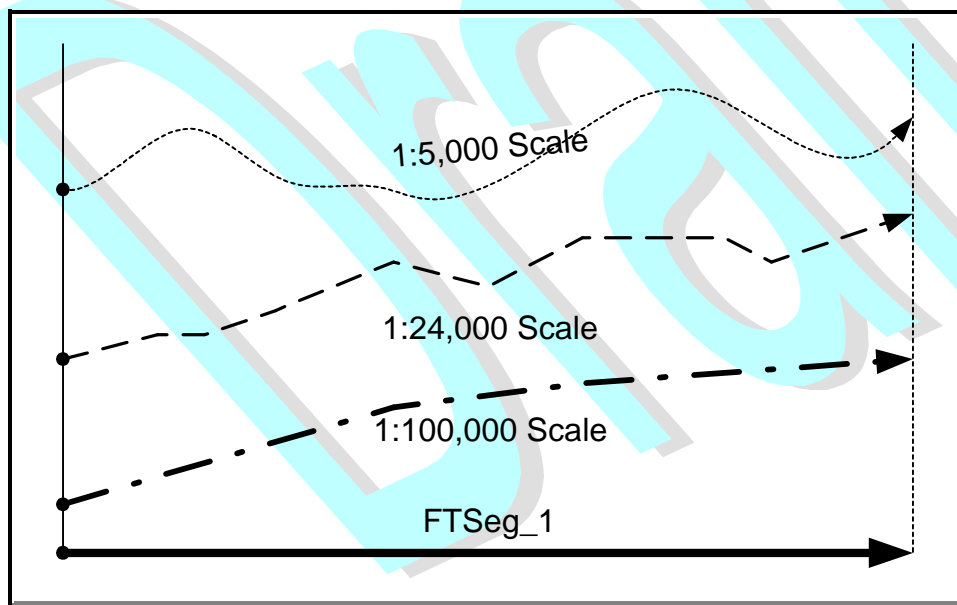

Figure 2 – Representation of a FTSeg and a variety of cartographic line
segments which it identifies

222   segments may be more or less complex, reflecting different scales of resolution, map

223   projections, or structural detail.

224   2.4   Connectivity of Framework Transportation Segments

225   FTSeg may be used to construct topological networks, but do not represent a topological

226   network by themselves. All topological relationships between entities in the data

227   standard are contained within the FTRP and FTSeg data records. Connectivity among

228   two or more FTSeg is defined either implicitly or explicitly.

229   2.4.1   Implicit Connectivity

230   Two FTSeg are said to be *implicitly*

231   connected if they share a common FTRP
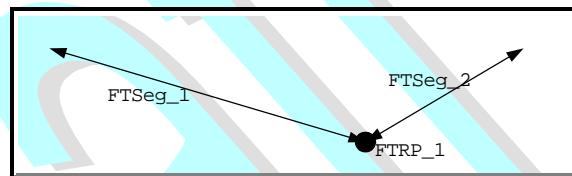
232   end point.

Figure 3 – Implicit Connectivity of two
FTSeg at FTRP_1

233   2.4.2   Explicit Connectivity

234   Two FTSeg are connected *explicitly* if the Segment-ID of one FTSeg appears in the

235   **FTSeg-ID** field (field #12) of an FTRP record which represents the "to" or "from" end

236   points of another FTSeg. In the following example P3 is an end point of FTSeg_2 and

237   P4 is an end point of FTSeg_3 . Neither point is an end point on FTSeg_1 , which is

238   made up of the entire line segment from P1 to P2.
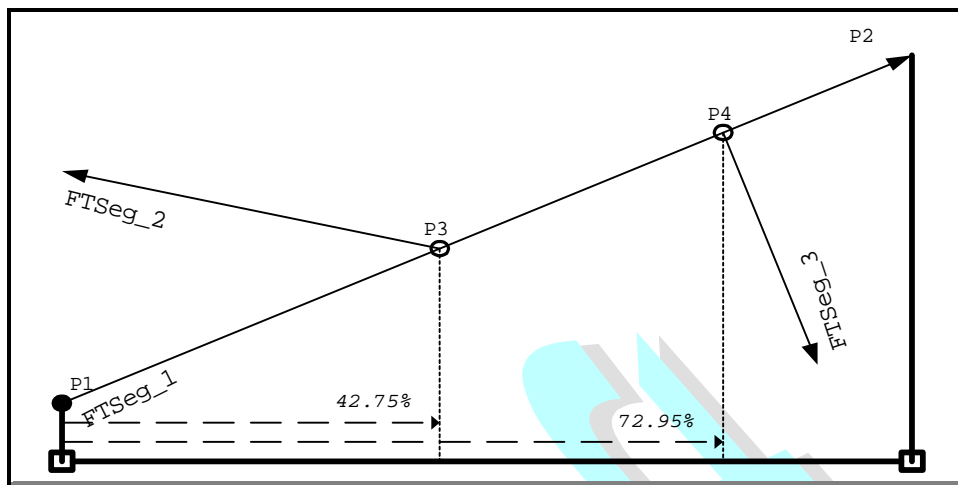
Figure 4 – Segments FTSeg_2 and FTSeg_3 are explicitly connected to
FTSeg_1 (See FTRP table below)

239   In the figure above `FTSeg_2` and `FTSeg_3` terminate on `FTSeg_1` at `P3` and `P4`

240   respectively. The values entered in the fields of the FTRP data records which provide for

241   connectivity are as follows:

Field #1- FTRP-ID	Fields #2 - #9	Field #12- FTSeg-ID	Field #13- FTSeg-Offset-%
P1	Other Data		
P2	"		
P3	"	FTSeg_1	42.75%
P4	"	FTSeg_1	72.95%

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248   2.4.3   Conditions lacking Connectivity

249   The topological properties of FTSeg consist exclusively of the implicit connectivity

250   resulting from a shared FTRP, and the explicit connectivity described above. This means

251   that FTSeg may cross one another without necessarily connecting. Further, two *different*

252   FTRP may exist at the *same location* without being connected.

253   FTSeg_1 and `FTSeg_2` may cross without

254   the need for a FTRP at the crossover, as in

255   the figure at right. There is no connectivity

256   between the physical transportation

257   segments illustrated in this figure; no
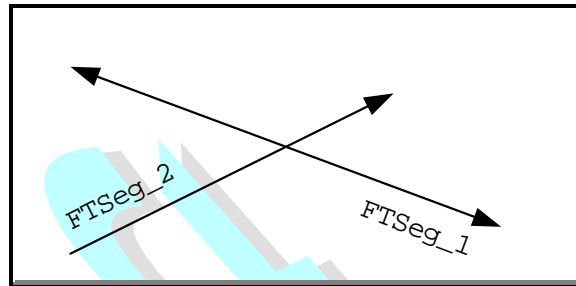
Figure 5

258   topological connection exists for such FTSeg unless a FTRP is defined in order to provide

259   for an explicit or implicit topological connection.

260   Multiple FTSeg may begin or end at the

261   same FTRP, and two such FTRP may

262   occupy the same location, without implying

263   either that the two FTRP are identical, or

264   that the two sets of FTSeg are connected.
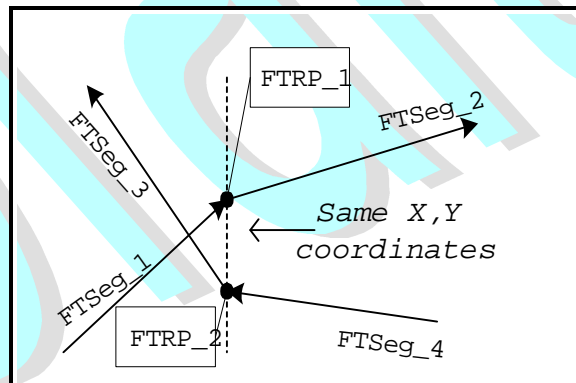
265   The figure at right shows that `FTSeg_1`

Figure 6

266   and `FTSeg_2` are connected implicitly at

267   `FTRP1`. Likewise `FTSeg_3` and `FTSeg_4` are connected implicitly at `FTRP2`.

268   Although `FTRP1` and `FTRP2` are in the same location, no implicit connection between

269   the two FTRP exists.

270   Using both implicit and explicit connectivity encoded in FTRP records, selected subsets

271   of FTSeg may be combined to create custom networks. The only requirement for the

272   derivation of such networks is that any FTSeg included in the network must connect --

273   implicitly or explicitly -- with another FTSeg that is also part of the network.

274   2.5   Relating Transportation Segments to Linear Referencing Systems

275   Once a network has been created, other transportation application layers can be built upon

276   it, including *identified routes, linear referencing methods*, and *linearly referenced points*

277   and *linear events*. All of these application layers can ultimately be mapped back to the

278   FTRP and FTSeg through the specific network links and nodes on which these

279   application layers were built. Geometric shape is not a required part of network *links,*

280   *routes,* or *linear events*. Any of these may be constructed without coordinates. All that is

281   required to construct the network layer (links and nodes) is the topological connections of

282   the FTSeg. Construction of routes and linear referencing methods is accomplished

283   through an ordered listing of the links (or parts of links) that comprise each route.

284   *EXAMPLE: Emergency service authorities may wish to define a "Road-Name" Route to*

285   *support vehicle dispatch. They can do so by defining the "official" road name as an*

286   *attribute associated with all or a part of each link. The ordered listing of all the links*

287   *associated with each "official" road name will define the "Road-Name" Route.*

288   2.6   Relating Attributes of Transportation Segments to FTRP and FTSeg

289   Organizations that wish to share information about different transportation databases will

290   have an interest in identifying those "real world" attributes (e.g. functional class, name or

291   route number, and street address ranges) of value within their applications. The

292   identification of such attributes, definition of their domains or formats is not a part of this

293   Standard.

294   Information about these attributes will be defined by national standards and practices, or

295   by the users of the data for a particular geography. Often the values of defined attributes

296   of linear features will not relate to 100% of the length of a particular FTSeg. These

297   attributes -- in addition to attributes pertaining to an FTRP or a complete FTSeg -- can be

298   shared by means of a table that relates the particular attribute values to one or more FTRP

299   or FTSeg, as follows:

#	Field_Name	Description & Format/Domain
1	FW-Transportation-Segment-ID-or-Reference-Point-ID	Permanent and unique identifier for the FTSeg or FTRP with which an attribute is associated
		Format specified in Section 2.7
2	Date	Date of creation of the attribute record
		Format YYYYMMDD
3	Authority-ID	Permanent and unique identifier of the authority which shares the attribute.
		Format specified in Section 2.9

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304	4	Start-Offset *(required if the ID in Field-1 identifies an FTSeg)*	Percentage offset from the FTSeg From-End-Point at which this attribute value commences; default value = "00.0000" A positive decimal number greater than or equal to "0" and less than "100" with format: +00.0000
305	5	End-Offset *(required if the ID in Field-1 identifies an FTSeg)*	Percentage offset from the FTSeg From-End-Point at which this attribute value ends A positive decimal number greater than "0" and less than or equal to "100" with format: +00.0000
306	6	Attribute-Name	Free text: 128 characters or less
307	7	Attribute-Value	Attribute value

308   Values are required for all fields. **Attribute-Name** and **Attribute-Value** apply to the

309   FTRP or FTSeg (or portion thereof) identified in field 1. Information about different

310   named attributes (e.g., "Route-#" and "Road-Name") must be conveyed in separate

311   records pertaining to each FTRP or FTSeg (or portion thereof). Metadata about each

312   named attribute should accompany the database table, and should conform to the FGDC

313   Content Standard for Digital GeoSpatial Metadata (version 2.0).

314   2.7 Unique Identifiers of FTRP and FTSeg

315   Each FTRP and FTSeg has a unique and permanent identification code of fixed length in

316   the following format:

317   **FTRP   --   AAAAA.XXXXXXXX**

318   **FTSeg   –   AAAAA.FF.XXXXXXXX**

319   2.7.1   Authority-ID

320   **AAAAA** – Each FTRP and FTSeg identifier includes the unique identifier of an

321   Framework Transportation Data Authority. This code identifies the organization which

322   generated the first database entry, or "originating" record describing the FTRP or FTSeg.

323   An Authority-ID also occurs in a separate data base field in each FTRP and FTSeg

324   record. This field records the identity of an authority which improves database records

325   about FTRP or FTSeg subsequent to the creation of the unique FTRP or FTSeg

326   identifiers. (Specifications for creating identifiers for each authority are the topic of a

327   following section.).

328   2.7.2   Feature Type

329   **FF** – Each FTSeg represents a portion of a linear transportation feature. The feature type

330   should be indicated, so as to allow the representation of connections between road and

331   non-road FTSeg. Allowable values are:

FF	Description
FE	Ferry - A scheduled conveyance of motorized vehicles across water from one FTSeg to another.
RR	Railroad - A maintained way consisting of two parallel rails for the passage of trains or trolleys

332, 333, 334

335	RD	Roadway - A cleared and maintained way for the passage of motorized vehicles
336	TR	Trail - A cleared path (as through woods or wilderness) not usually trafficked by motorized vehicles because of width or seasonal conditions, or
		A trail (e.g. bike path) which is not intended for the use of motorized vehicles

337   2.7.3   Numeric Code

338   **XXXXXXXX** is a zero-filled non-meaningful numeric identifier of eight characters in

339   length for each FTRP or FTSeg.

340   2.8 Relating "Logical" to "Physical" FTRP and FTSeg

341   2.8.1   Equivalent FTRP and FTSeg

342   An FTRP or FTSeg which is assigned a Category of "physical" represents a point or a

343   transportation segment over which a vehicle can pass while remaining within the traveled

344   way. Traveled ways separated by a physical barrier may be represented by two physical

345   FTSeg, and each physical FTSeg must begin and end at a physical FTRP. Many data

346   authorities will maintain databases in which traveled ways separated by a physical barrier

347   are represented by two sets of arcs, which can be mapped as separate lines.

348   However, other data authorities may maintain databases in which parallel traveled ways

349   separated by a physical barrier are represented by a single set of arcs; e.g. a small-scale

350   representation of an Interstate

351   highway. Such authorities

352   may create and/or use FTRP

353   and FTSeg which are

354   assigned a category of

355   "logical." The figure at right

356   illustrates the representation

357   of a physically divided

358   traveled way in a "Large-
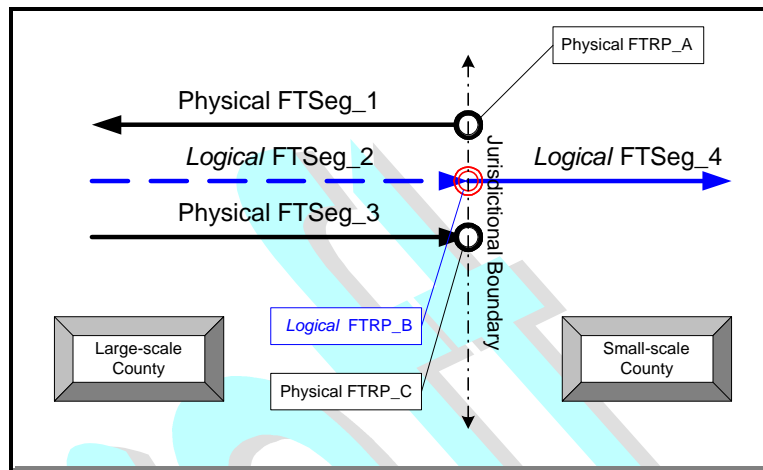
Figure 7 - Connectivity between "Single line" and "Dual line" representations of a Divided Roadway

359   scale county" as two (physical) segments in one database (`FTSeg_1` and `FTSeg_3`), and

360   as a single (logical) segment (`FTSeg_2`) in another database. All three FTSeg records

361   must be connected to the segment `FTSeg_4`, which represents the continuation of the

362   same road within the contiguous "small-scale" county. `FTSeg_2` and `FTSeg_4` are

363   implicitly connected at `FTRP_B`; however, the connectivity of "logical" `FTSeg_4` with

364   "physical" `FTSeg_1` and `FTSeg_3` must be accomplished through entries in the

365   equivalency table.

366   2.8.2   The Equivalency Table

367   At points of connectivity between such differing representations of the traveled way(s) all

368   physical segments must be capable of connecting with the logical segment(s) in databases

369   that represent the features in contiguous jurisdictions; the inverse is also true. And

370   wherever multiple authorities maintain databases describing equivalent features within

371   the same jurisdiction (i.e., the representations are of the same point or line features), the

372   logical and physical FTRP and FTSeg must be related through entries in the equivalency

373   table, so they can support exchange of attribute across these databases.

374   Equivalence is sustained by the maintenance of data records that capture relationships

375   between physical and logical FTRP and FTSeg. One physical FTRP may have 0 or 1 or

376   more logical FTRP which are equivalent. Also, one physical FTSeg may have 0 or 1 or

377   more logical FTSeg which are equivalent. Since one logical FTRP (or FTSeg) may also

378   have 0 or 1 or more physical FTRP (or FTSeg) which are equivalent, the table supports

379   "many-to-many" relationships, and is in the form of an unordered list of tuples:

#	Equivalency Table Field-Name	Description & Format/Domain
1	FTRP_ID or FTSeg_ID	Permanent and unique identifier for the FTRP or FTSeg Format specified in Section 2.7
2	Equivalent_FTRP_ID or Equivalent_FTSeg_ID	Permanent and unique identifier for the FTRP or FTSeg which is equivalent Format specified in Section 2.7

380

381

382

383   Figure 7 (above) above shows that physical `FTSeg_1` and `FTSeg_3` are equivalent to

384   logical `FTSeg_2`. Likewise, the FTRP which terminate these segments are equivalent:

385   physical `FTRP_A` and `FTRP_C` are

386   equivalent to logical `FTRP_B`. Multiple

387   entries in the table, as illustrated, will

	ID	Equiv-ID
RecNum-1	FTSeg_1	FTSeg_2
RecNum-2	FTSeg_3	FTSeg_2
RecNum-3	FTRP_A	FTRP_C
RecNum-4	FTRP_B	FTRP_C

388   establish these equivalencies; the ordering of

389   the entries, and which element of the tuple is recorded in which field makes no difference.

390   Users of the multiple representations of these transportation features in both counties will

391   be able to link entries in the equivalency table to the information in their own databases

392   about FTRP and FTSeg, and thereby access information maintained by other authorities.

393   2.9   Framework Transportation Data Authorities

394   An NSDI Framework Transportation Data Authority may perform some or all of the

395   functions necessary to build and operate the NSDI Framework. These functions are: *Data*

396   *Development, Maintenance, and Integration, Data Access, Data Management,*

397   *Coordination, Executive Guidance, Resource Management* , and *Monitoring and*

398   *Response*.[2]

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[2]NSDI Framework Introduction and Guide, FGDC, 1997, Chapter 4.

399   Any organization which takes responsibility for proposing, designating, or working in

400   partnership with other organizations to define FTRP and FTSeg is -- for the purposes of

401   this standard -- operating as an "authority." Organizations which act as authorities

402   1) create or update transportation databases (or plan to do so),

403   2) share those databases or related attribute sets with others (or plan to do so), and

404   3) conform database development and maintenance activities to this standard.

405   Each authority is identified by a permanent, unique, fixed-length code of five characters

406   in the form of **AAAAA**.   Information about each authority is maintained in an NSDI

407   Framework Authority Index; (See Part 3 - Implementation Procedures).

408   2.9.1   Unique Identifiers for Single-state authorities

409   Organizations which perform authority functions in one state or any part of one state will

410   assume a unique identifier, the first two characters of which consist of the state FIPS

411   code. These characters will duplicate the first two characters in the first section of the

412   FTRP or FTSeg record for many local and state transportation-related public agencies.

413   The following three characters consist of a unique code for each authority located within

414   the state. *EXAMPLE: The Vermont Agency of Transportation could assume an*

415   *Authority-ID of "50001," the Vermont Enhanced-911 Board could assume the Authority-*

416   *ID of "50002," with other state-specific state, regional and local agencies assuming*

417   *other identifiers.*

418   2.9.2   Unique Identifiers for Multi-state authorities

419   Federal agencies, organizations which produce data for multiple states, and non-domestic

420   authorities can all be accommodated by using the code of "00" in the first two characters.

421   The remaining three characters consist of a code unique to each authority. Multi-state

422   authorities which have multiple database maintenance operations or separate geographic

423   units can assume separate Authority-IDs. *EXAMPLE: Some federal agencies which are*

424   *FGDC members perform data development and maintenance in facilities in multiple*

425   *regions of the US. Such regional data maintenance facilities may choose to become*

426   *authorities, and each should use a unique code beginning with "00."*

427   2.9.3   Descriptive Attributes for each Authority

428   The information content relating to each authority maintained within the index is based

429   on the "Contact-Information" content specified within the FGDC "Content Standard for

430   Digital GeoSpatial Metadata". It includes the following information:

431

#	Authority Field-Name	Description & Format/Domain
1	**Authority-ID**	Permanent and unique identifier of the organization.
		Five character integer

432

433	2	Authority-Name	Name of the organization acting as an authority
			Free text: 255 characters or less
434	3	Contact-Person-Primary	Name of a contact person
			Free text: 255 characters or less
435	4	Contact-Voice-Telephone	Voice telephone number of Contact-Person-Primary
			Free text: 10 characters
436	5	Contact-Facsimile-Telephone *(optional)*	Fax telephone number of Contact-Person-Primary
			Free text: 10 characters
437	6	Contact-Electronic-Mail - Address *(optional)*	E-mail address of Contact-Person-Primary
			Free text: 255 characters or less
438	7	Contact-URL *(optional)*	Universal Resource Locator for Internet access to the Authority
			Free text: 255 characters or less
439	8	Contact-Instructions	Instructions for contacting the Authority
			Free text: 255 characters or less
440	9	Authority-Address	Mail delivery address of the Authority
			Free text: 255 characters or less
441	10	Authority-City	Mail delivery city of the Authority
			Free text: 255 characters or less
442	11	Authority-State-or-Province	Mail delivery state (US) or province (non-US) of the Authority
			Free text: 255 characters or less
443	12	Authority-Postal-Code	Mail delivery ZIP (US) or postal code of the Authority
			Free text: 10 characters or less
444	13	Authority-Country	Mail delivery Country of the Authority
			Free text: 20 characters or less

445	14	Authority-Information *(optional)*	Information about the geographic area, types of transportation activities, or data maintenance operations in which the Authority is engaged
			Free text: 255 characters or less
446	15	Index-Access-Information	Information on obtaining access to or a copy of information contained in the authority's FTRP and FTSeg information
			Free text: 255 characters or less

1   3.   **Appendices**
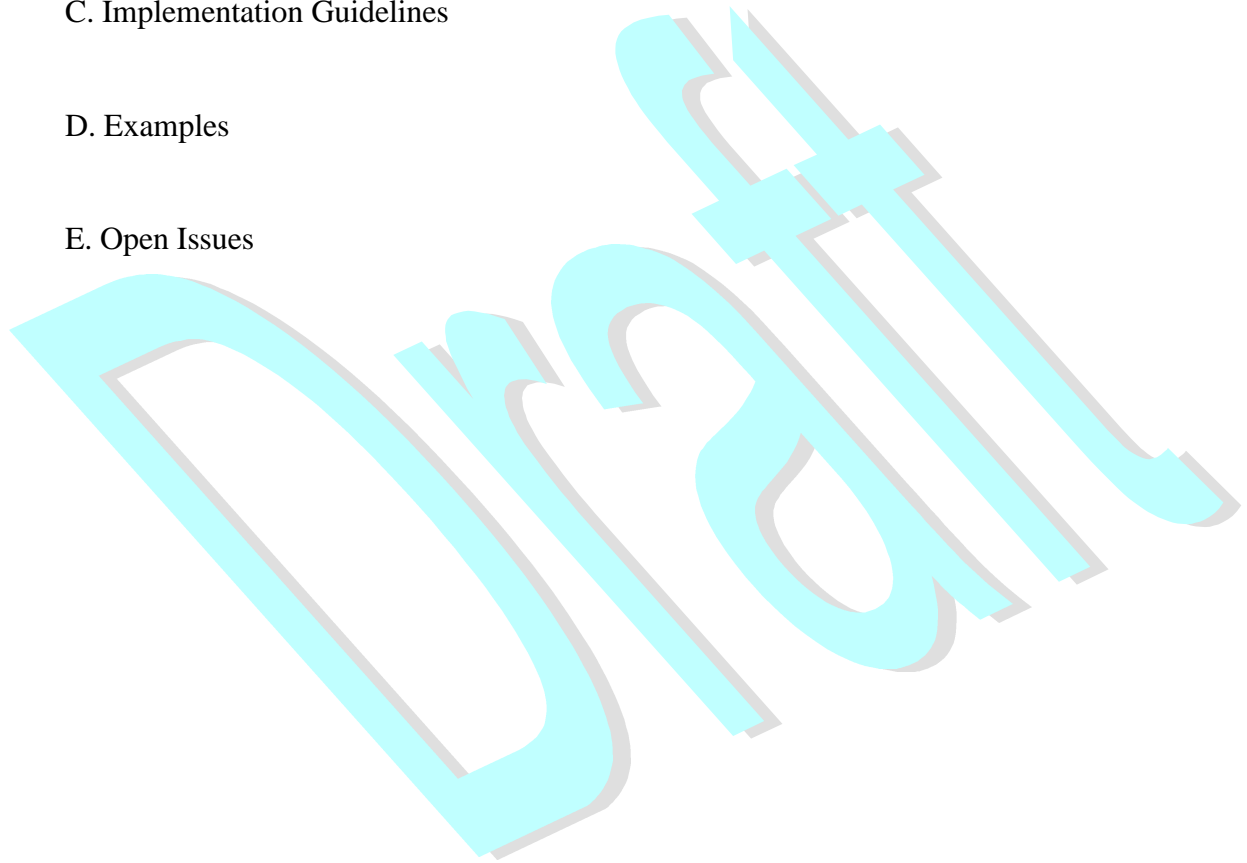

2   A. Terminology

3   B. References

4   C. Implementation Guidelines

5   D. Examples

6   E. Open Issues

7   Appendix A

8   **Terminology**

9   (Informative)

10   Terms used throughout this document, with reference to broader technical glossaries

11   developed by other organizations

12   Definitions for the terms and concepts presented in this section have been extracted from

13   a variety of sources. Where appropriate, language has been retained from existing

14   definitions, including from the Spatial Data Transfer Standard (SDTS), by the FGDC

15   Ground Transportation Subcommittee, the NCHRP Report 359, and concept and

16   workshop papers recently authored by Vonderohe, Dueker, and Fletcher et al. When

17   utilized, specific references to these sources appear in parentheses following the

18   definitions.

19   **Anchor point**. A zero-dimensional location that can be uniquely identified in the

20   real-world in such a way that its position can be determined and recovered in the field.

21   Anchor points serve as a geodetic control mechanism to facilitate construction of a linear

22   datum model and/or route network (Vonderohe).

23   **Anchor section**. A continuous, directed, non-branching linear feature, connecting two

24   anchor points, whose real-world length (in distance metrics) can be determined in the

25   field. Anchor sections are specified as having a "from" anchor point and a "to" anchor

26   point and a "distance" attribute (Vonderohe).

27   **Arc**. A locus of points that forms a curve that is defined by a mathematical expression

28   (SDTS).

29   **Chain**. A directed non-branching sequence of nonintersecting line segments and (or) arcs

30   bounded by nodes, not necessarily distinct, at each end (SDTS).

31   **Framework Transportation Reference Point (FTRP)**. The specified location of one

32   endpoint of a Framework Transportation Segment on a physical transportation system.

33   **Framework Transportation Segment (FTSeg)**. A specified directed path between two

34   Framework Transportation Segment Reference Points along a physical transportation

35   system that identifies a unique segment of that physical system.

36   **Line**. A generic term for a one-dimensional object. Lines can be defined variously as

37   "line segment," "string," "arc," or "chain." Lines have shape and position (SDTS).

38   **Line segment**. A direct line between two points (SDTS).

39   **Linear datum**. The collection of objects which serve as the basis for locating the linear

40   referencing system in the real world. The datum relates the data base representation to the

41   real world and provides the domain for transformations among linear referencing systems

42   and among geographic representations. The datum consists of a connected set of anchor

43   sections that have anchor points at their junctions and termini (Fletcher). A linear datum

44   is not based upon a network with GIS geometry, but instead is properly considered to be

45   an abstract representation of objects (lines, nodes) that describes how the objects are

46   related.

47   **Linear Referencing Method** (LRM). A mechanism for finding and stating the location

48   of an unknown point along a network by referencing it to a known point (Vonderohe).

49   Common methods include milepost, link-node, route-segment-offset, and addresses.

50   **Linear Referencing System** (LRS). The procedures that relate all location referencing

51   methods to each other, including office and field techniques for storing, maintaining, and

52   retrieving location information (O'Neill).

53   **Link**. A topological connection between two ordered nodes (Vonderohe, SDTS). Links

54   do not necessarily have shape or position.

55   **Link-Node**. A location referencing method based upon a unique numbering system

56   describing links (or arcs) and nodes; it does not inherently contain measurement data.

57   **Location.** The name given to a specific point on a highway for which an identification of

58   its linear position with respect to a known point is desired. (TRB, 1974)

59   **Location Reference Method (Highway)**. The technique used to identify a specific point

60   (location) or segment of a highway, either in the field or in the office. (TRB, 1974)

61   **Location Reference System (Highway)**. The total set of procedures for determining and

62   retaining a record of specific points along a highway. The system includes the location

63   reference method(s), together with the procedures for storing, maintaining, and retrieving

64   location information about the points and segments on the highways. (TRB, 1974)

65   **Milepost/Milepoint/Reference Post**. A commonly used location referencing method.

66   Location of features is specified as a measured distance or offset from a known point such

67   as an intersection. In the field, reference posts may be used as the primary known point.

68   **Network**. A graph without two-dimensional objects or chains. An aggregation of nodes

69   and links representing a topological object (SDTS, Vonderohe). A network implies that

70   there is a graphic connectivity, or topology, among elements.

71   **Node**. A zero-dimensional object that is a topological junction of two or more links, or an

72   end point of a link or chain (Vonderohe, SDTS).

73   **Point.** A zero-dimensional object that specifies location. A pair or triplet of coordinates

74   specifies location.

75   **Reference Object**. A physical object which is not readily movable (e.g. curb

76   intersection, bridge end, traffic signal pole, survey marker) that can easily be found in the

77   field and represented as a point on a map.

78   **String**. A connected non-branching sequence of line segments specified as the ordered

79   sequence of points between those line segments (SDTS).

80   **Topology**. Spatial relationships and connectivity among graphic GIS features, such as

81   points, lines, and polygons. These relationships allow display and analysis of "intelligent"

82   data in GIS. Many topological structures incorporate begin and end relationships,

83   direction, and right/left identification.

84   **Traversal**. An ordered and directed, but not necessarily connected, set of whole links

85   (Vonderohe).

86   **Traversal Reference Point**. A zero-dimensional location along a traversal that is used to

87   reference events along the traversal (Vonderohe).
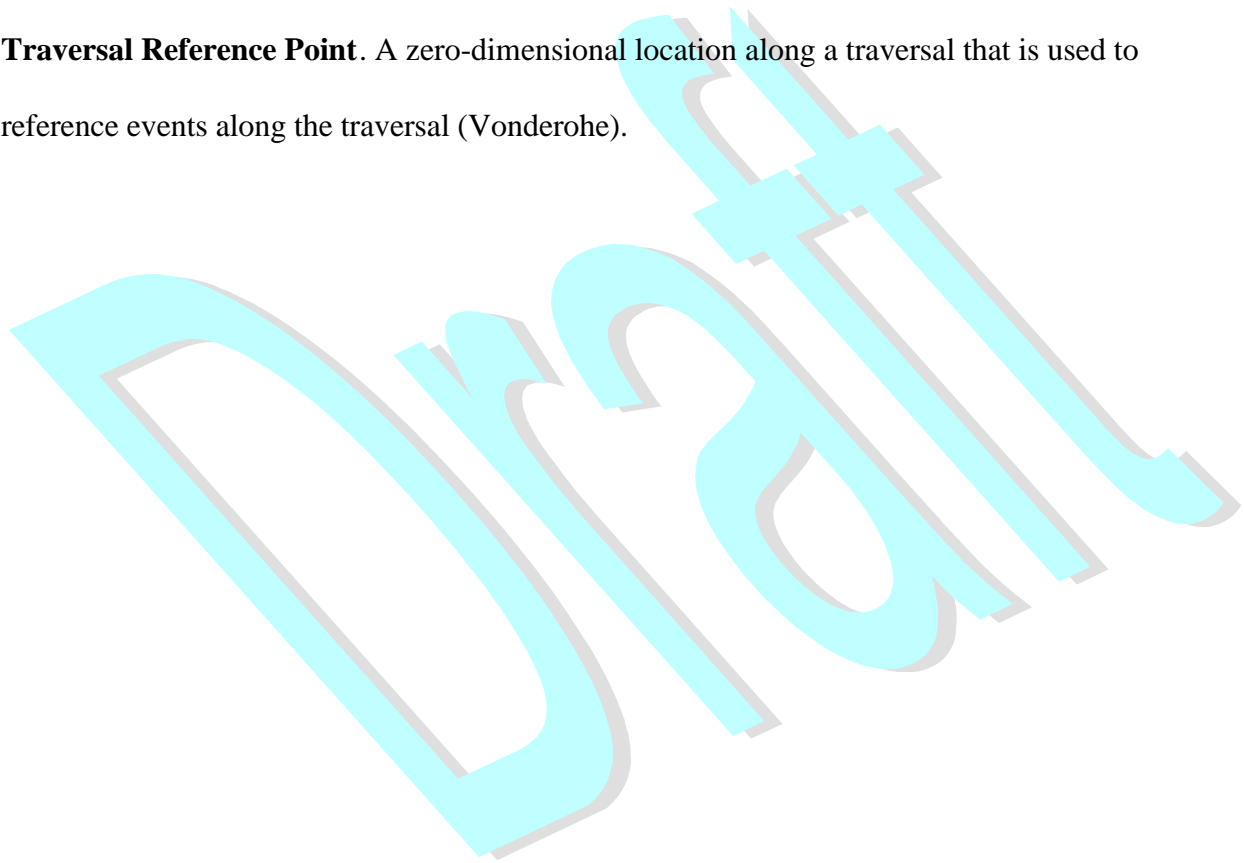
88   Appendix B

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1   **1   IMPLEMENTATION PROCEDURES**

41 **1   IMPLEMENTATION PROCEDURES**

42 This section includes guidelines for placement of Framework Road Segments (FTSeg)

43 and Framework Road Segment Reference Points (FTRP). It also describes recommended

44 procedures for implementing this standard, conventions for cartographic display of FTRP

45 and FTSeg, and conformance testing.

46 The NSDI Framework Transportation Identification Standard imposes only one constraint

47 with respect to how a physical road is partitioned into FTSeg: segments must not span

48 state borders. This section therefore provides a set of guidelines for placing FTRP and

49 creating FTSeg that are expected to meet the needs of a great many – but not all – of

50 those organizations that wish to participate in sharing road information. These guidelines

51 are intended to be compatible with the practices of organizations that support network

52 applications and require connectivity of the links and nodes which correspond to the

53 FTSeg and FTRP defined in this standard.

54 The procedures recommended in these guidelines are consistent with the level of detail

55 found in maps at scales ranging from 1:12,000 to 1:24,000. Many transportation

56 databases are being created at these scales by digitizing from USGS quadrangles or from

57 standard Digital Orthophoto Quarter Quadrangles (DOQQs). This section offers

58 procedures and rules of good practice intended for use at this scale: other users

59 developing databases at smaller or larger scales may need to consider departures from

60   these procedures. These procedures are specifically not applicable to users whose

61   applications are based on CAD-scale engineering databases that graphically depict

62   roadway widths, curbs, right-of-ways, etc.

63   FTSeg should be created to represent those segments of roads about which attributes

64   (including cartographic shape) are to be shared among organizations. Segmentation of

65   roads into links which are specific to particular network applications (e.g., driveway-to-

66   driveway road segments for E-911 dispatch, shopping center parking lots for transit

67   buses, or back alleys for trash collection) do not require FTSeg unless they have

68   associated with them information useful to other users or applications.

69   Road data authorities should coordinate the development of a road data base with all

70   relevant stakeholders, particularly with respect to which roads should be included in a

71   local implementation. The decision of which roads to include should reflect a reasonable

72   compromise between an economical number of FTRP and FTSeg, and common network

73   application needs of the stakeholders. *Example: A local E-911 agency may wish to*

74   *incorporate intersections of local roads with private driveways. However, such a data*

75   *structure would proliferate the number of FTSeg in the road database. Unless other*

76   *cooperating road data authorities agree that this structure is useful, they should place*

77   *FTRP only at intersections of public roads; the E-911 agency can create a supplemental*

78   *road database using explicit connectivity to join driveways to local roads.*

79   1.1   Establishing Framework Road Segment Reference Points (FTRP)

80   Each FTRP must be categorized as either "Physical" or "Logical;" FTRP that are

81   "physical" represent a point on or at the end of a FTSeg over which a vehicle can pass

82   while remaining within the traveled way. FTRP that are "logical" are most often those

83   used in small-scale representations of more complex physical features. Examples of

84   "logical" points include single-point representations of complex intersections. The FTRP

85   placement guidelines below apply to points which are either physical or logical.

86   1.1.1   At Jurisdictional Boundaries

87   FTRP should be placed wherever a road crosses a jurisdictional boundary between two

88   road data authorities. The road data authorities on either side of the jurisdictional

89   boundary should coordinate the identification and placement of the FTRP so that one

90   common FTRP is used to identify the crossing point. *Example: Two neighboring states*

91   *should coordinate identification of FTRP at their common boundary with each other and*

92   *with contiguous counties and/or other jurisdictions (where pertinent) who share the same*

93   *boundary line(s).*

94   1.1.1.1   State and International Borders

95   FTRP must be placed wherever a road crosses a state border, regardless of whether or not

96   there is a designated road data authority in the adjoining state or country. Such FTRP

97   should terminate FTSeg representing any road which intersects the border.

98   1.1.1.2   County Boundaries

99   Authorities should consider placing an FTRP wherever a road crosses the boundary

100   between two counties within a state. Even in those cases where the delineation of a

101   county boundary is not easily located in the field, placement of an FTRP could facilitate

102   coordination with authorities and road data users on either side of the boundary.

103   1.1.2   Simple Road Intersections

104   A FTRP should be placed wherever two roads of similar functional class or importance

105   cross one another at grade. Roads segments which share a common FTRP are implicitly

106   connected and therefore do not require additional information to establish connectivity in

107   any application network built from the road data. Road data authorities should identify

108   those roads for which they want to ensure connectivity in all network applications and

109   place FTRP at each intersection. *Example: A state DOT may wish initially to construct a*

110   *statewide road base map, consisting only of state highways, U.S. routes and Interstate*

111   *highways. FTRP would be placed only at the intersections of these roads. Intersections*

112   *with county and local roads could be accommodated at some future time through explicit*

113   *connectivity to FTSeg on the statewide road base map.*

114   A single FTRP can be created to represent the

115   intersection of two roads; it can be used to

116   terminate segments on one or both intersecting

117   roads (illustrated in Figure 1 as segments "A-B"

118   and "C-D" .) A cartographic convention used in

119   this figure places an arrow-head at FTRP_1,

120   where the FTRP breaks "C-D' into two

121   segments[1]. Segment "A-B" passes through the
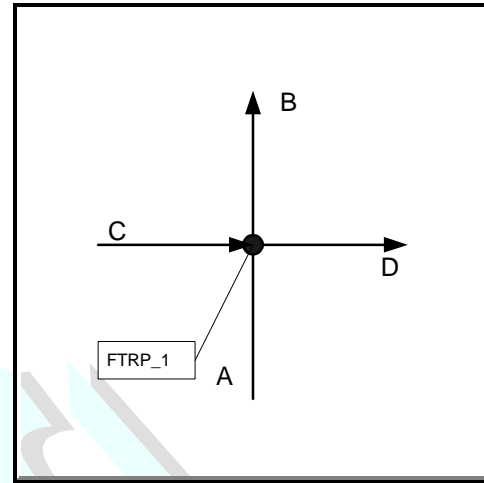
Figure 1 Simple Road Intersection

122   same point unbroken, as is indicated by the lack of an arrow-head, which would represent

123   the terminus of two segments. FTRP_1 provides implicit connectivity between the two

124   segments for which it serves as a terminus -- in this Figure the two segments going from

125   "C" to "D." If it serves to segment just one of the two crossing paths (as illustrated in

126   Figure 1) then the FTRP data record also provides for explicit connectivity to the

127   unbroken other path – in this Figure the single segment going from "A" to "B."

128   1.1.3   Offset Intersections

129   Occasionally, one road may intersect another at two distinct intersections offset by a short

130   distance. In order to avoid creating a very short FTSeg, road data authorities should use

131   an FTRP to represent implicit connectivity at only one of the intersections. Depending on

---

[1]See Implementation Procedures – Section 1.8 for recommenced cartographic conventions.

132   the level of spatial resolution represented in the road database, the second (offset)

133   intersection may be joined using explicit connectivity, or the offset distance may be

134   ignored and treated as a conventional at-grade intersection.

135   1.1.4   Overpasses and Underpasses

136   FTRP may be placed at grade-separated crossings such as overpasses or underpasses in

137   order to meet several needs. First, if placed at such a crossing the FTRP could represent

138   the implicit connectivity of two segments which terminate on the upper grade or the

139   lower grade. Similarly, if segments terminate on both roads, two separate FTRP should

140   be used to represent connectivity at the upper and lower termini. Finally, an FTRP can be

141   placed at such an intersection and not serve as a terminal point of any segment; i.e., it

142   could serve only as an "intermediate-point" of one of the segments. In summary,

143   placement of a FTRP at such a location requires users to provide additional information

144   in any network applications, so that users do not make unsupported assumptions about

145   implicit connectivity.

146   1.1.5   Grade-Separated Interchanges

147   Grade-separated interchanges consist of one or more overpasses, and entrance and exit

148   ramps to connect the otherwise non-intersecting main roads. In general, a FTRP does not

149   need to be placed at the location of the overpassing roads if network connectivity can be

150   established using the ramps. However, road data authorities may wish to place FTRP at

151   interchanges in order to create manageable length road segments. *Example: On limited-*

152   *access highways a state DOT may choose to establish FTSeg that go from interchange to*

153   *interchange.*

154   If an FTRP is placed at a grade-separated interchange, it should only connect one of the

155   two crossing roads, not both. In other words, the FTRP should serve as the end point for

156   only two FTSeg, either the over passing road or the under passing road, but not both. If

157   the transportation data authority chooses to segment both roads at the interchange, two

158   unique FTRP should be created, one connecting the over passing road, and one

159   connecting the under passing road. These FTRP may either be assigned the same X-Y

160   coordinate values, or may be offset from one another.

161   1.1.5.1   Entrance and Exit Ramps

162   An FTRP should not terminate a segment of a road at every gore point (i.e., intersection)

163   where the road is joined by entrance or exit ramps. To do so would divide the road into a

164   large number of very short FTSeg in the vicinity of the interchange. Entrance and exit

165   ramps are better handled using explicit connectivity to join the end point of the ramp to

166   the main road at some specified offset distance along a segment of the road.

167   1.2   Establishing Framework transportation Segments (FTSeg)

168 A single FTSeg represents an unambiguously defined path along a physical transportation

169 network between two FTRP. In most instances, FTRP can and should be selected in such

170 a way that there is only one path between them along a transportation network In cases

171 where two or more uninterrupted paths exist between the same two FTRP, the fields for

172 Intermediate-Point and Path-Description in the FTSeg record must be used to differentiate

173 among the paths.

174 Each FTSeg must be categorized as either "Physical" or "Logical;" segments that are

175 "logical" are most often those used in small-scale representations of more complex

176 physical features. An FTSeg which is "physical" represents an transportation segment

177 over which a vehicle can pass while remaining within the traveled way. An FTSeg

178 should be designated as physical ONLY if it begins and ends at a physical FTRP.

179 Examples of "logical" segments include single-line representations of divided highways.

180 The FTSeg placement guidelines below apply to points which are either physical or

181 logical.

182 Each "real world" transportation segment should be described by one, and only one,

183 "physical" FTSeg and by no more than one FTSeg identifier categorized as "logical."

184 Transportation data authorities with overlapping responsibilities for a geographic area

185 should coordinate the identification of FTSeg and establishment of equivalency between

186 "physical" and "logical" FTSeg. *Example: A state DOT and a county road authority are*

187 *both responsible for building a road framework data base for the county. The technical*

188   *staff for each agency should agree on which agency has responsibility for identifying*

189   *FTSeg of which roads (e.g., the state DOT authority designates FTSeg for all Federal*

190   *and state sign routes, while the county authority designates FTSeg for all county routes*

191   *and local roads).*

192   1.2.1   Segment Length

193   The appropriate FTSeg length represents a tradeoff between maintaining information on a

194   large number of short segments, and potential errors introduced by measurements over a

195   long linear segment. This standard prohibits segments which span state boundaries.

196   Transportation data authorities within a particular geography will need to assess whether

197   more restrictive guidelines regarding FTSeg length are needed to support common

198   applications among various transportation database users within that geography.

199   1.2.1.1   Roads that Cross Jurisdictional Boundaries

200   Roads that cross state and county jurisdictional lines should be represented by FTSeg that

201   terminate at the boundaries. Consequently, no FTSeg should be longer than the driving

202   distance across a state; in all but the most rural areas, authorities should consider

203   terminating FTSeg at county boundaries.

204   1.2.1.2   Roads that Coincide with Jurisdictional Boundaries

205   Roads which run along a jurisdictional boundary should be represented by FTSeg whose

206   length does not exceed the line dividing the jurisdictions. When a road runs along a

207   jurisdictional boundary for a portion of the boundary length, a FTSeg should be

208   terminated where it leaves the boundary line, and a new FTSeg should be initiated –

209   except in locations where local authorities determine that the departure from the boundary

210   line is insignificant. Part III-D of this standard provides an example.

211   1.2.2   Road Types

212   The decision to represent a particular road by a single logical FTSeg or two or more

213   parallel physical FTSeg should be based on scale, accuracy, cartographic and network

214   application requirements. In general, network applications are facilitated where FTSeg

215   and FTRP can be directly replaced by network links and nodes. These guidelines are

216   aimed at minimizing additional work beyond establishing explicit connections for FTSeg

217   to create a flowable transportation network.

218   1.2.2.1   Roads with no Access Restrictions or Medians

219   One-way and two-way roads with no significant access restrictions or physical median

220   separating directional roadways should be represented by a single FTSeg. Most local

221   streets, connectors, and minor arterials fall into this category.

222   1.2.2.2   Roads with Center Medians but no Access Restrictions

223   Some major urban and rural arterials have a center median which divides the travel lanes

224   in each direction (e.g., Commonwealth Avenue in Boston). However, intersecting streets

225   can access either direction of travel lanes via short transportation segments crossing the

226   median at each intersection. These roads may be represented either by a single FTSeg

227   which ignores the center median, or by two parallel FTSeg depicting directional roadways

228   on either side of the median. If parallel FTSeg are used, intersecting FTSeg should be

229   terminated at only one of the two parallel FTSeg, not both. (See Figure 4.)

230   1.2.2.3   Limited-Access Divided Highways

231   Most Interstate Highways and major, high speed expressways can only be entered or

232   exited via specifically designated ramps. These roads almost always have some median

233   strip or other physical barrier that prohibits vehicles from reversing direction without first

234   exiting the highway at a designated ramp. These roads should always be represented by

235   two FTSeg regardless of the actual physical separation between the lanes (e.g., even roads

236   which are separated by a concrete "Jersey Barrier" should represented by two FTSeg if

237   each direction is served by its own entrance and exit ramps.) (See Figures 2 & 3.)

238   1.2.2.4   Physically Separated, Limited-Access Parallel Lanes

239   Some high volume roads, particularly in urban areas, may designate certain lanes for high

240   occupancy vehicles (HOV) or auto-only, and physically separate these lanes from the

241   main travel lanes (e.g., I-395 in northern Virginia, or the New Jersey Turnpike outside

242   New York City). If these physically separated lanes are served by their own entrance and

243   exit ramps, they should be represented by their own FTSeg. Furthermore, if the priority

244   lanes are also separated directionally, each direction should be represented by its own

245   FTSeg. *Example: The northern end of the New Jersey Turnpike includes physically*

246   *separated auto-only lanes, running parallel to the main traffic lanes in both directions.*

247   *Both the main lanes and the auto-only lanes have their own entrance and exit ramps.*

248   *This facility should be represented by four parallel FTSeg – one for each direction of the*

249   *main lanes and one for each direction of the auto-only lanes.*

250   1.2.2.5   Entrance and Exit Ramps

251   Entrance and exit ramps are one-way or two-way roads that provide general vehicle

252   access to limited-access highways. Each entrance or exit ramp should be represented by a

253   FTSeg. FTRP which terminate entrance or exit ramps should use explicit connectivity to

254   join with the main road which the ramp accesses.

255   1.2.2.6   Frontage Roads

256   A frontage or access road is a one- or two way, unlimited-access surface street that

257   parallels but is physically separated from a more limited-access major arterial. Its main

258   purpose is to provide access to establishments along the major arterial corridor while

259   preventing access traffic from disrupting the flow of through traffic on the major arterial.

260   Access from the frontage road to the major arterial is typically limited to intersections of

261   cross-streets and/or specifically designated "gaps" in the median or physical barrier.

262   Frontage roads should be represented by their own FTSeg. Entrance "gaps" between the

263   frontage road and the main arterial should be treated similar to an entrance or exit ramp.

264   1.2.2.7   "Stacked" Highways

265   A stacked highway occurs when one road or directional roadway is built above another

266   roadway. Although the two roads are separated vertically, when displayed on a two-

267   dimensional surface (e.g., map or computer monitor) they appear as a single line. Each

268   road or directional roadway should always be represented by its own FTSeg, regardless of

269   how they might be displayed.

270   1.2.3   Complex Intersections

271   The preceding guidelines provide rules for placing FTRP and using FTSeg to represent

272   various types of transportation features in a generally consistent way and without creating

273   short, difficult to locate FTSeg. The following examples illustrate some typical

274   combinations of roads and intersections and how they might be represented using FTRP,

275   FTSeg, and explicit connectivity relationships.

276   1.2.3.1   Full Interchange, Two Limited-Access Divided Highways
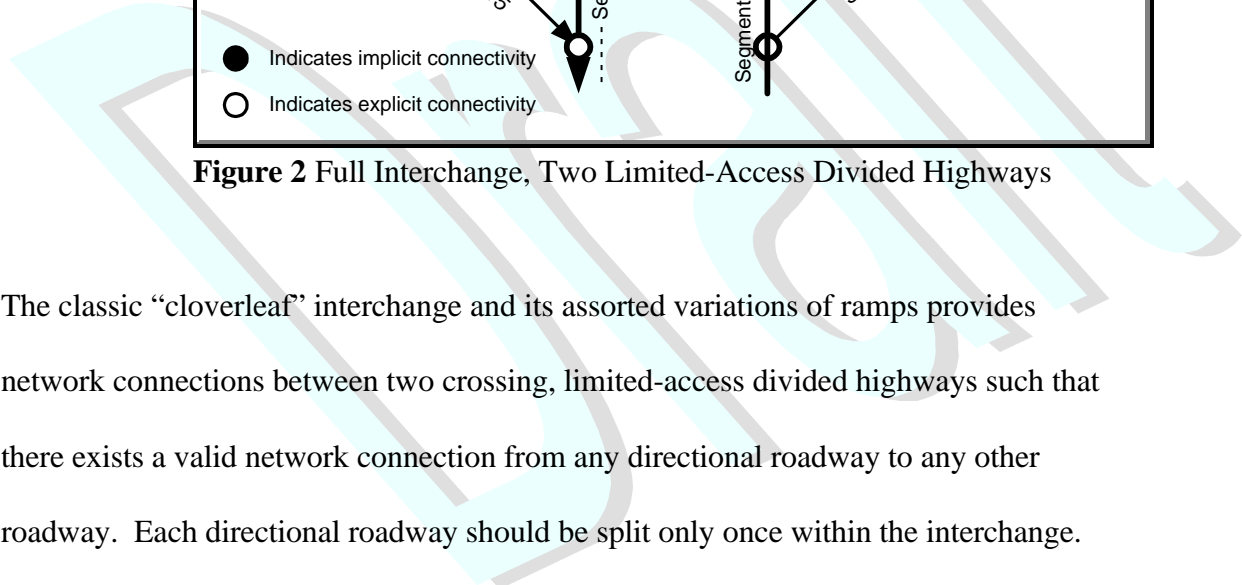
Figure 2 Full Interchange, Two Limited-Access Divided Highways

277   The classic "cloverleaf" interchange and its assorted variations of ramps provides

278   network connections between two crossing, limited-access divided highways such that

279   there exists a valid network connection from any directional roadway to any other

280   roadway. Each directional roadway should be split only once within the interchange.

281   This can be done by splitting each incoming directional roadway where it first crosses

282   (either as an overpass or underpass) a directional roadway of the other highway. Only the

283   incoming FTSeg is split; the FTRP does not split the crossing directional roadway at this

284   point; the "Note" in Figure 2 highlights this. The resulting configuration consists of four

285   FTRP, one at each of the four corners of the intersecting directional roadways. However,

286   each of these FTRP connects only two of the four apparently intersecting lines. Ramps

287   are added to the interchange using explicit connectivity to join each endpoint of the ramp

288   to one of the directional roadways of the crossing highways. The resulting interchange

289   consists of eight FTSeg for the main highways (each of the four directional roadways is

290   split into two FTSeg), and up to eight FTSeg for the interchange ramps.

291   1.2.3.2   "Diamond" Interchange

292   The classic "diamond" interchange provides a network connection between a limited-

293   access divided highway and a two-way surface roadway. On the divided highway, each

294   directional roadway should

295   be split where it crosses

296   (either as an overpass or

297   underpass) the two-way

298   street. As with the full

299   cloverleaf interchange, the

300   FTRP on the directional

301   roadway does not split the

Figure 3 "Diamond" Interchange

302   crossing two-way street. The two-way street should be split either by a second FTRP

303   assigned the same X-Y coordinate values as one of the two FTRP of the directional

304   roadways, or by a FTRP located "between" the two directional roadways, as illustrated

305   above. Ramps are added to the interchange using explicit connectivity to join one
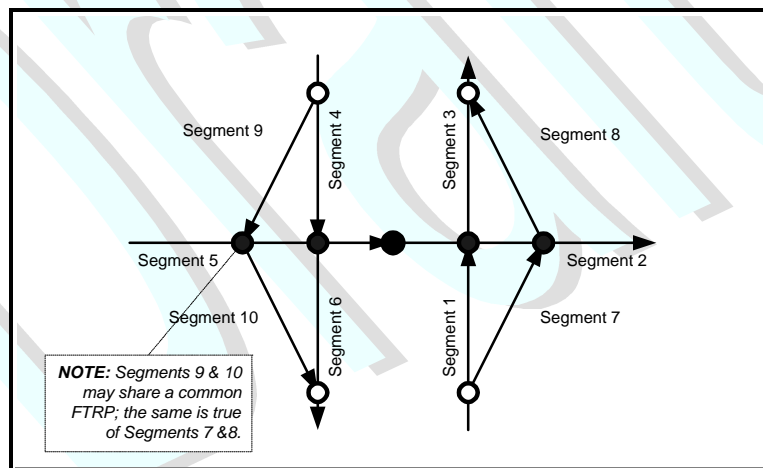
306   endpoint of the ramp to one of the directional roadways of the divided highway and the

307   other endpoint to a location on the two-way roadway. The resulting interchange consists

308   of six FTSeg for the crossing roads, and four FTSeg for the interchange ramps.

309   1.2.3.3   Intersection: Two-Way Surface Street with a Center Median Surface Street

310   This intersection looks similar to the "diamond" interchange, except that there are no

311   overpassing roads: the two-way crossing street actually intersects each directional

312   roadway. In order to avoid

313   creating a very short

314   FTSeg representing the

315   road surface crossing the

316   median area, a single

317   FTRP should be placed at

318   one of the two

319   intersections that splits

320   both the crossing two-way

Figure 4 Intersection: Two-Way Surface Street with a
Center Median Surface Street

321   roadway and one of the two directional roadways. This is labeled as "FTRP-2" in the

322   Figure above. The other directional roadway should be split with a FTRP -- labeled as

323   "FTRP-1" -- that indicates explicit connectivity to the FTSeg that represents the crossing

324   two-way road. The resulting intersection consists of six FTSeg and two FTRP.
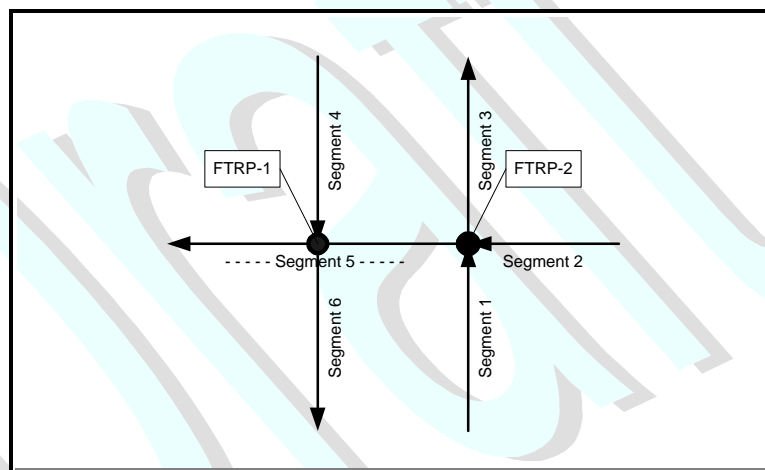
325   1.2.3.4   Traffic Circle

326   A traffic circle consists of a circular loop road that is intersected by several other roads

327   which radiate outward from the circle.   The traffic circle should be represented either as a

328   single FTSeg that begins

329   and ends at the same FTRP

330   (illustrated in Figure 5), or

331   by two FTSeg that each

332   represent some portion of

333   the circle.   The FTRP

334   marking the intersection of

335   each radiating road should

Figure 5 Traffic Circle

336   be connected to the traffic circle FTSeg using explicit connectivity to avoid creating short

337   FTSeg between each radiating road. The path description for the FTSeg representing the

338   traffic circle should include a direction (either clockwise or counterclockwise) to indicate

339   the order in which the radiating roads intersect. One of the radiating roads may share the

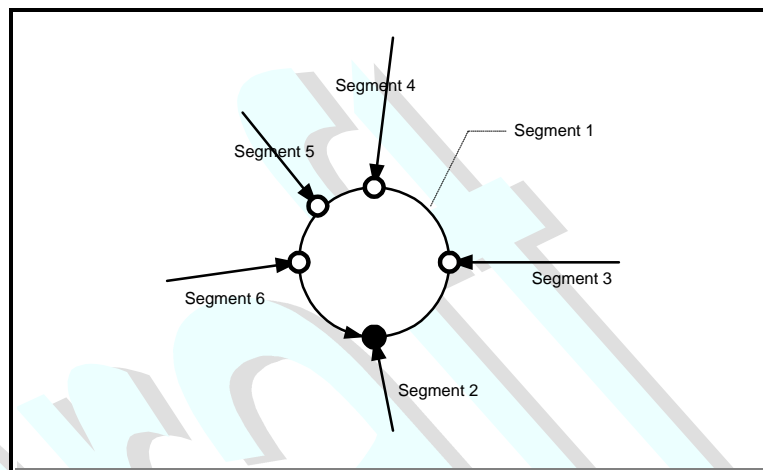340   same FTRP as the traffic circle FTSeg.

341   1.3   Creating New or Updated FTSeg and FTRP

342   Multiple FTRP and FTSeg records can exist for any point or segment, because their

343   multi-part key includes "Authority-ID" and "Date". *"Creating"* FTRP and FTSeg refers

344   to generating a new record keyed with a new and unique identifier. *"Updating"* FTRP

345   and FTSeg refers to creating a new database record(s) with an already-defined identifier,

346   new and unique "Authority-ID" and/or "Date" information, and new or updated

347   information in other fields.

348   In the normal course of events authorities will update records (using the same FTRP-ID

349   or FTSeg-ID, with a different "Date", and possibly a different "Authority-ID".) These

350   will reflect improvements in description or measurement for the same point or segment –

351   even if there is no change in the "real world" features represented by the FTRP or FTSeg.

352   1.3.1   Reconstruction

353   New FTRP and/or FTSeg records must be created when FTRP are relocated and FTSeg

354   are re-defined during the (re-)construction of roads or changes in intersection alignment.

355   This requires retirement of old FTRP and associated FTSeg, and creation of updated

356   FTRP and FTSeg, as described below. The unique identifier for FTRP and/or FTSeg

357   records which are retired as a result of (re)construction may be encoded within other

358   FTRP and/or FTSeg records to which the retired objects are implicitly or explicitly

359   connected. Therefore the references in these other records must be updated with the

360   identities of the objects which have replaced the retired objects.

361   1.3.2   Re-measuring

362   FTRP and/or FTSeg records should be updated when more accurate measurement of

363   coordinates/lengths are obtained. This entails creating new records with a unique key

364   made up of the FTSeg-ID and/or FTRP-ID, the Authority-ID, and the Date, updating the

365   information in other fields (as appropriate), and carrying forward information from fields

366   which are not updated.

367   1.4   Retiring FTSeg and FTRP

368   1.4.1   Road (re)construction

369   As stated above, new FTRP and FTSeg should be created during the (re-)construction of

370   roads — addition of ramps, or changes in intersection alignment. Those FTRP and

371   FTSeg used exclusively to designate the (old) feature which has been reconstructed

372   should be retired by changing the "Status" of all records which identify the (old) feature

373   from "A" (active) to "R" (retired).

374   1.4.2   FTRP Duplication

375   Instances can occur in which two authorities create unique FTRP IDs which identify the

376   same "real world" feature.

377   1.4.2.1   Before identifying new FTRP each authority should evaluate existing FTRP

378   records maintained in the distributed index, and should coordinate with other

379   authorities concerned about the same or contiguous geography, in order to

380   prevent such duplication. Analysis of the"AAAAA" substrings and the

381   coordinates of existing FTRP identifiers will in most cases allow an authority to

382   avoid duplication.

383   1.4.2.2   When authorities verify that duplicate FTRP-IDs exist for the same feature,

384   they should retain the unique ID which has the earliest date of assignment.

385   Other records which describe the same feature but use a redundant ID should be

386   retired by changing the "Status" of all records containing the FTRP-ID of the

387   redundant entity as "R" (retired). Any useful information which is contained

388   within these (retired) records should be copied into active records that contain

389   the ID which has been retained, and that are identified uniquely as to

390   "Authority-ID" and "Date". *Example: Two neighboring jurisdictions use and*

391   *update two different road base maps, and have not coordinated activities in the*

392   *past. They independently identify FTRP at their shared borders. They should*

393   *review coordinate and description data in order to select and analyze possible*

394   *duplicates, whether at the level of a sub-county border, a county border, or a*

395   *state border. They should retain the oldest of any redundant records as*

396   *"active," update these with any useful information from records which are to*

397   *be retired, and change the status of newer records to "retired."*

398   1.5   The Distributed Index of Transportation Authorities, FTSeg, and FTRP

399   1.5.1   Transportation Authorities

400   Part II of this standard describes the role of NSDI Framework Transportation Authorities

401   and the coding of a unique identifier and attributes for each. Designation as an authority

402   is voluntary and self-initiated by any organization which performs the role(s) described.

403   1.5.1.1   Initial Assignment and Maintenance

404   The initial assignment and maintenance of each unique authority identifier will be

405   performed by the FGDC or a participating agency. These functions will be implemented

406   within a WWW-based software application providing for data entry and validation,

407   assignment of an ID and password, and search and download functions.

408   1.5.1.2   Access

409   Provision of access to the indexed database of authorities and the public dissemination of

410   information about each authority will be the ongoing responsibility of the FGDC or a

411   participating agency. Access and information about authorities will be available through

412   the WWW and in printed form.

413   1.5.2   Points and Segments

414   Part II of this standard describes the specification of Framework Road Segments and

415   Framework Reference Points, and the coding of unique identifiers, the record structure,

416   and attributes for each. This section describes the procedures by which records

417   describing each point and segment are established, maintained, and made accessible to

418   the public.

419   1.5.2.1   Initial Assignment (Creation) and Maintenance of FTSeg and FTRP Records

420   (voluntary & distributed)

421   The FGDC or one of its participating agencies will implement a WWW-based software

422   application providing for data entry and validation, assignment of an ID and password,

423   and search and download functions. This database application will operate in a fashion

424   very similar to the FGDC Metadata Clearinghouse application.

425   The index will operate on a central server(s), and the same application will be provided to

426   Authorities who wish to provide their own indices of FTSeg and FTRP. The data will be

427   maintained on this decentralized network of servers – each authority need not operate the

428   application; multiple Authorities can cooperate in hosting the application. Search,

429   display and download functions will be publicly accessible. Each Authority will have the

430   secure ability to make add-modify transactions for records containing the unique

431   Authority ID.

432   1.5.2.2   Access

433   Provision of access to the indexed database of FTSeg and FTRP, and the public

434   dissemination of information about the data will be the ongoing responsibility of the

435   FGDC or a participating agency, and of participating Authorities. Access and

436   information about FTSeg and FTRP will be available through the WWW and in printed

437   form.

438   1.6   Defining FTSeg and FTRP within a Geographic Area

439   The implementation of this standard requires development of consensus among a limited

440   number of authorities who create and update transportation data within a specified

441   geographic area. Those participating will have a thorough knowledge of NSDI

442   Framework principles and roles, and will likely be performing several of the identified

443   functions of Framework management. The tasks that they will have to accomplish in

444   order to implement this standard are summarized below.

445   1.6.1   Geographic Extent

446   Implementation of the standard should be attempted within an explicitly bounded

447   geographic area consisting of one state, or a sub-state area. The extent of this area must

448   be determined by all organizations which may wish to share data within the area, or to

449   become cooperating authorities. Often the choice made will be closely linked with the

450   following task.

451   1.6.2   Cooperating Authorities

452   All organizations which develop or maintain road centerline databases should be

453   informed of efforts to implement the standard, and should be invited to participate.

454   Agencies of the U.S. Departments of Interior, Transportation, Commerce, and others may

455   want to participate, depending upon the geographic area. It is likely that successful

456   completion of this and related tasks depends upon the willingness of one organization to

457   assume a leadership role in gaining the cooperation of others. Each participating

458   organization should recognize that the incentive to incur the workload of implementation

459   consists of future enhancements in its ability to share data which supports key business

460   functions, and consequent reductions in the costs of sharing data.

461   Those organizations that agree to implement the standard should make their commitment

462   explicit, and should determine that the institutional relationships required for data sharing

463   with others are or can be put in place. Other organizations which operate applications

464   that require or would benefit from improved sharing of transportation data – but which do

465   not actually develop or maintain data – should also be informed. No commitment is

466   required from these other organizations.

467   1.6.3   Contiguous Jurisdictions

468   Major state-level or sub-state data producers in contiguous jurisdictions should be

469   identified and informed of efforts. The current status of data sharing operations at

470   relevant jurisdictional lines should be assessed. When practical, organizations which

471   might serve as authorities should be identified, and their cooperation in identifying FTRP

472   at boundaries should be sought.

473   1.6.4   Inventory of Databases and Applications

474   Once the questions of "Who?" and "Where?" have been addressed, participants should

475   inventory all transportation database development and maintenance operations which will

476   be affected by the implementation of the standard. Participants should also inventory the

477   applications which depend upon the transportation data, and the value of the improved

478   data sharing which is likely to result from use of the standard. Particular attention should

479   be given to the networks which have been developed, their commonalities and

480   differences. The common requirements of applications will lead authorities to determine

481   whether or not county and/or local and/or private roads should be included in an initial

482   implementation.

483   1.6.5   Base Data for Initial Assignment

484   Participants will have to examine available data assets to determine the extent to which

485   nationally or locally available sets of names, points and lines, or links and nodes may

486   provide a "starting point" for implementation. *Example: In a large rural area, locally-*

487   *enhanced TIGER line file data and a "starter set" of points such as the ITS Datum*

488   *Prototype Version 1.1 CD may provide the basis for determining the local scope of an*

489   *initial implementation of the standard. In a more urbanized area where road names are*

490   *well-known, used, and stable, a larger-scale local database which includes network*

491   *nodes and links based on unique road names may be a better point for initial creation of*

492   *FTSeg and FTRP records.*

493   1.6.6   Prototype Implementation

494   Within a limited section of the geographic area cooperating authorities should do a

495   prototype implementation, utilizing this standard and other locally-developed guidelines

496   for achieving FTRP densities and FTSeg spans that best meet their needs. All data

497   records should be accorded the STATUS of "Proposed." All cooperating authorities

498   should then attempt to embed the FTRP and FTSeg identifying information within their

499   own data structures, determine any difficulties, and agree on refinements in the

500   implementation. Following implementation of the prototype, cooperating authorities

501   should determine the sequence and timing of operations to implement the standard within

502   the geographic area selected. Authorities should populate identifying records in the Index

503   of Authorities, and cooperators should identify the Index of FTRP and FTSeg which will

504   be the registry for their information.

505   1.7   Establishing Object Identity and Connectivity

506   Each Framework transportation data developer will have to know some characteristics of

507   multiple transportation databases which may be under development or maintenance

508   within the developer's geographic extent, and those which may exist at the boundaries of

509   that extent. The data developer may not be able to implement this standard in such a way

510   as to assure that all users will be able to relate and connect their databases for all

511   purposes. *Example: In a particular jurisdiction two authorities may have separate*

512   *representations of the same transportation features; differences in scale and applications*

513   *could mean that some roads are represented by parallel FTSeg for one authority, and by*

514   *single FTSeg for the other. Each developer will need to make additional application-*

515   *based decisions about the logical relationship between the single-line and dual-line*

516   *representations of the same physical transportation segments and the relationship of*

517   *attributes associated with each, in order to share each others' information.*

518   1.7.1   Implementation Sequence (Overview)

519   Data developers can establish object identity relationships and connectivity by making the

520   following analysis of their Framework transportation environment:

521   1.7.1.1   Inventory Transportation Data Organizations and Databases – What

522   organizations maintain transportation data within the geographic extent in

523   question? At its boundaries?

524   What transportation databases exist within this area? At its boundaries? At

525   what scale, with what spatial accuracy, and with what attribution?

526   1.7.1.2   Assess Current and Projected Conformance with this Standard – Are these

527   organizations registered Framework Transportation authorities? Do they plan

528   to become authorities?

529   Do registered FTSeg and FTRP exist within this area? Do registered FTRP

530   exist at its boundaries?

531   1.7.1.3   Utilize Existing FTSeg and FTRP as much as Practical – Have other

532   Authorities identified FTSeg which represent the same transportation features

533   in your database?

534   Can you utilize existing FTRP to define new FTSeg, updating FTRP records

535   when helpful, and identifying new FTRP only when necessary?

536   1.7.2   Implementation Sequence (Detail)

537   1.7.2.1   Inventory Transportation Data Organizations and Databases

538   Designation of FTSeg and FTRP should not be undertaken without an understanding of

539   the specific business benefits which will accrue. Most often these are benefits which

540   arise from sharing data with other database developers within the specific geography,

541   and/or from establishing connectivity with transportation databases covering contiguous

542   jurisdictions.

543   Identification of all organizations which are or may become authorities within and

544   contiguous to the specific geography is necessary to the building of a "business case" for

545   implementing the Standard. The technologies used, business missions, and policy

546   environments of all such organizations should be well-understood, as they impact the

547   ability of organizations to participate in the NSDI Framework. Likewise, all

548   transportation databases which might be pertinent to sharing or connectivity should be

549   inventoried as to scale, accuracy and attribution, in order to better understand the

550   potential costs and benefits of sharing data or connecting to them.

551   1.7.2.2   Assess Current and Projected Conformance with this Standard

552   Identification of any transportation databases which are candidates for inclusion in the

553   NSDI Framework should lead to more detailed analysis. A data developer who will

554   implement this Standard should:

555   1.7.2.2.1   Identify other registered Framework transportation authorities operating within

556   or contiguous to the specific geography;

557   1.7.2.2.2   Develop thorough FGDC-standardized metadata for Framework transportation

558   databases, and acquire metadata for other candidate databases maintained by

559   other authorities;

560   1.7.2.2.3   Determine applicability of other relevant standards to the databases, and assess

561   compliance with those standards;

562   1.7.2.2.4   Determine whether registered FTRP exist within this area, or at its boundaries,

563   and whether FTSeg have already been identified within this area.

564   1.7.2.3   Utilize Existing FTSeg and FTRP as much as Practical

565   A data developer should seek to utilize the unique identifiers of all FTRP and FTSeg

566   which describe the same physical transportation features as are represented in the

567   candidate database. A data developer who will implement this Standard should:

568   1.7.2.3.1 Identify all registered FTRP and FTSeg which exist within and at the boundary

569   of the specific geography

570   1.7.2.3.2 Acquire a copy of the database(s) in which FTSeg identifiers are assigned to the

571   spatial data, and encode the same FTSeg on the appropriate segments in the

572   candidate database. *Example: Figure 2 might illustrate FTSeg identified by two*

573   *different authorities. A developer of a "larger scale" database might*

574   *implement this Standard in an area where a developer of"intermediate scale"*

575   *data had already identified Segments 1-8. The first developer should utilize*

576   *these FTSeg identifiers, updating FTRP records as necessary, and should add*

577   *new ones only for Segments 9-16.*

578   1.7.2.3.3 Create new FTRP records only when necessary. FTRP are required as

579   termination points for each FTSeg, required to establish the uniqueness of

580   multiple paths between a pair of FTRP, and may be used at other locations.

581   Creation of new records should follow procedures stated in the following

582   section.

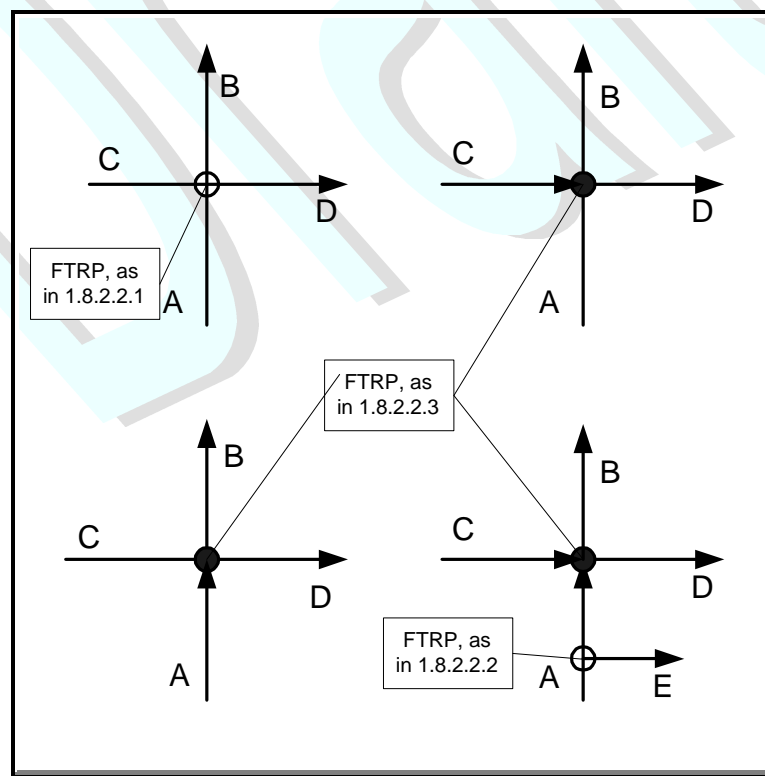583   1.8   Cartographic Representation of FTRP and FTSeg

584   1.8.1   Display of County and State Density

585   The state to which each FTSeg record pertains is encoded within the unique identifier, as

586   is the state in which an Authority operates (with some exceptions.) This information,

587   plus the coordinates of FTRP, can be used to display general location and density of

588   FTRP and FTSeg records.

589   1.8.2   Display of FTRP and FTSeg

590   Coordinate values (horizontal) and related accuracy statement fields are required within

591   each FTRP record. Availability of this information will allow the cartographic display of

592   point locations along with information about the known accuracy of each. Cartographic

593   representation of a FTSeg requires that it be linked to table(s) of attributes which include

594   the coordinates of shape

595   points. The following

596   display conventions are

597   recommended, and are

598   illustrated in Figure 6:

599   1.8.2.1   FTSeg should be

600   depicted either

601   by straight lines

602   connecting two

603   FTRP or by

Part III-C Pg. 32

604   curved lines (if two or more FTSeg terminate at the same two FTRP.) Each

605   FTSeg should be displayed as a line terminating in a single "arrow-head" at the

606   "To-FTRP" terminus. Various line symbols and widths may be used.

607   1.8.2.2   FTRP should be symbolized as circles.

608   1.8.2.2.1 FTRP which do not lie at the terminus of any FTSeg should be represented by

609   an open circle.

610   1.8.2.2.2 FTRP which lie at the terminus of one FTSeg and represent explicit

611   connectivity should be represented by an open circle.

612   1.8.2.2.3 FTRP which lie at the terminus of two or more FTSeg should be represented by

613   a circle which is completely filled.

614   1.8.3   Relationship to Other Cartographic Elements

615   FTRP and FTSeg identifiers will be encoded as attributes associated with lines and

616   intersections within geographic information systems, and associated with links and nodes

617   in network representations. Cartographic representations which utilize FTRP and FTSeg

618   should be carefully symbolized, labeled and/or annotated so that users do not impute to

619   the FTRP and FTSeg position or precision which is not warranted, or confuse them with

620   links and nodes. FTSeg have no shape points or inherent geometry, and need not have a

621   measured length. Users will associate them with arcs and chains contained within their

622   datasets, and display them as such. Such display of FTSeg will be necessary during the

623   process of their initial definition and subsequent updates, and will be helpful to many

624   users.

625   1.9   Conformance Testing

626   FTSeg and FTRP consist of information which can be structured into tables of

627   information, and then exchanged with others who find the information useful, or

628   combined into larger tables of like information. FTRP and FTSeg may relate to spatial

629   features, objects, or spatial data records contained within individual geographic

630   information systems. But FTRP and FTSeg are intended to be developed and exchanged

631   without implied or linked topology or geometry. Consequently this standard does not

632   include specifications relating to geometry or topology. Conformance tests are specified

633   in order to assure that the information associated with each FTRP and FTSeg -- and with

634   related attributes -- meets stated content requirements, and that the format of each record

635   is compatible with that used by others who create or update FTSeg and FTRP records.

636   1.9.1   Record Content

637   1.9.1.1   The content of each of the following fields in the FTRP and FTSeg records

638   shall fall within the specified range or domain, as described in Part II of this

639   standard.

640   1.9.1.1.1 The content of the substring of unique FTSeg identifiers referred to as "FF"

641   shall conform to this standard.

642   1.9.1.1.2 The content of the substrings of unique FTRP and FTSeg identifiers referred to

643   as "AAAAA" and the content of the field "Authority-ID" within FTRP and

644   FTSeg records shall be verifiable when compared against the unique identifiers

645   maintained in the NSDI Framework Authority Index.

646   1.9.1.1.3 The content of the substrings of unique FTRP and FTSeg identifiers referred to

647   as "XXXXXXXX" shall consist of eight numeric characters (0-9).

648   1.9.1.1.4 The content of all date fields shall be valid dates greater that "19990101"

649   1.9.1.1.5 In records detailing related attributes the value of the "End-Offset" shall be

650   greater than the value of the "Start-Offset."

651   1.9.1.2   The content of other required fields in each FTRP, FTSeg, and related attribute

652   record shall be within specified domains.

653   1.9.1.3   The content of each conditional field in FTRP and FTSeg records shall be

654   within specified domains when the stated condition is "true."

655   1.9.1.4   The content of each optional field in FTRP and FTSeg records, when present,

656   shall be within specified domains.

657   1.9.2   Consistency of FTRP and FTSeg Records

658   1.9.2.1   The unique identifiers FTRP named as the From-End-Point and To-End-Point

659   within an FTSeg record must exist within the distributed registry of FTRP, and

660   the unique identifier of the FTSeg-ID required in some FTRP records must

661   exist within the distributed registry of FTSeg.

662   1.9.2.2   FTSeg and FTRP Category Consistency

663   1.9.2.2.1 For any FTSeg record, if the **Category** is "P"(Physical), the FTRP **Category**

664   for the (required) From-End-Point and To-End-Point and the (optional)

665   Intermediate-Point must also be "P"(Physical).

666   1.9.2.2.2 If the FTRP **Category** is "L"(Logical), the FTSeg **Category** of every FTSeg for

667   which the unique FTRP is identified as a From-End-Point or a To-End-Point or

668   an Intermediate-

669   Point must also be

670   "L"(Logical).

671   Four FTSeg and four FTRP

672   in Figure 7 are assigned

673   **Category** = "P" (Physical)

674   because (by definition) they

An undivided road splits into two traveled ways for
a short length. Segments 1,3,4 and 5 are PHYSICAL,
while FTSeg_2 is a LOGICAL "single-line"
representation of the divided traveled way.
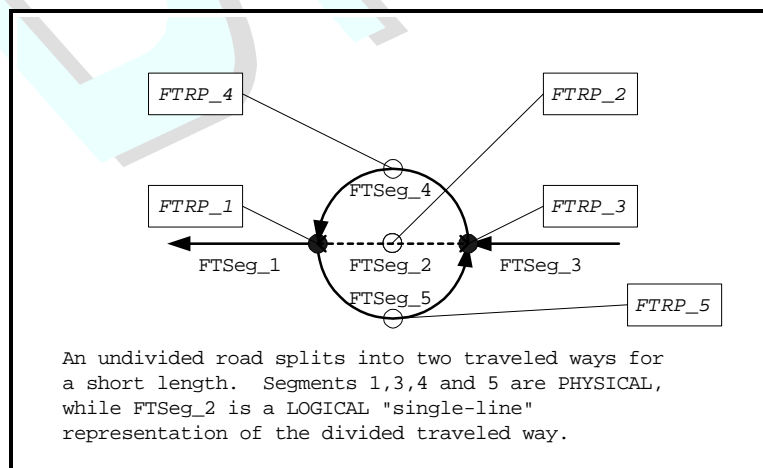
Figure 7 - "Physical" and "Logical" FTSeg

675   fall in the traveled way. Only FTSeg_2 and FTRP_2 are categorized as "L" (logical)

676   because (by definition) they do not fall in the traveled way.

677

IF:	THEN:
FTSeg-Category = "P"	FTRP-Category must equal "P" for the From-End-Point and To-End-Point and Intermediate-Point
FTSeg-Category = "L"	FTRP-Category may equal "P" or "L" for the From-End-Point or To-End-Point, but must equal "L" for the Intermediate-Point
FTRP-Category = "L"	FTSeg-Category must equal "L" for all FTSeg in which the FTRP is recorded as the From-End-Point or To-End-Point or Intermediate-Point
FTRP-Category = "P"	FTSeg-Category may equal "P" or "L" for any FTSeg in which the FTRP is recorded as the From-End-Point or To-End-Point, but must equal "P" for any FTSeg in which the FTRP is recorded as the Intermediate-Point

678   (row 1)

679   (row 2)

680   (row 3)

681   (row 4)

682   1.9.3   Record Format

683   Data described in this Standard should be exchanged in a common (ASCII) format which

684   can be generated and interpreted by commercial-off-the-shelf (COTS) software.

685   1.9.3.1 The first line of characters contained in the file should consist of "FTRP" or

686   "FTSeg" or "Attribute" or "Equivalency" or "Authority" , followed by a

687   <Carriage Return / Line Feed> to indicate the type of content in the file.

688   1.9.3.2   Each record contained in the file should commence on a new line, may be of

689   variable length, and should conclude with <Carriage Return / Line Feed>.

690   1.9.3.3   Each field should be part of the record -- even if blank (null), and should be of

691   the specified format and length, with the exception of free text fields, which

692   should not exceed the specified length. Each field should be separated from the

693   field preceding and following by a <Tab> character.

694   1.9.4   Validation

695   The FGDC shall provide computer software which can read and interpret files of

696   information formatted as specified. The software shall include a facility for performing

697   all checks on record content specified in this standard, and for providing the user with

698   reports detailing features of particular records which do not meet specifications for

699   content.

1   Appendix D

2   **Examples**

3   (Informative)

4   The following are intended to serve as examples of how users of this standard might

5   implement and maintain information about FTRP and FTSeg.

21   **1   Improvements in FTRP over time**

22   Within a particular geographic area additional FTRP can be identified over time, and

23   existing FTRP can be improved by the creation of newer records containing upgraded

24   Locational_description, Accuracy_statement or coordinate values. The addition or

25   improvement of existing FTRP is not a matter of improving density or accuracy of points,

26   as most often understood in establishment of geodetic control. Nor need the sequence or

27   densification of FTRP over time correspond to a "top-down" hierarchy in the

28   development of Framework transportation data.

29   Most typically FTRP extracted from Federal-level databases will be less dense and less

30   accurate, because of the scale and the transportation features of interest to Federal users

31   of data. FTRP derived from local-level databases will very likely contain more complete

32   locational_descriptions and accurate coordinates and – where such databases exist – may

33   be developed sooner than (or instead of) FTRP derived from at the Federal level.

34   The figure at right is

35   intended to illustrate how a

36   FTRP which serves as the

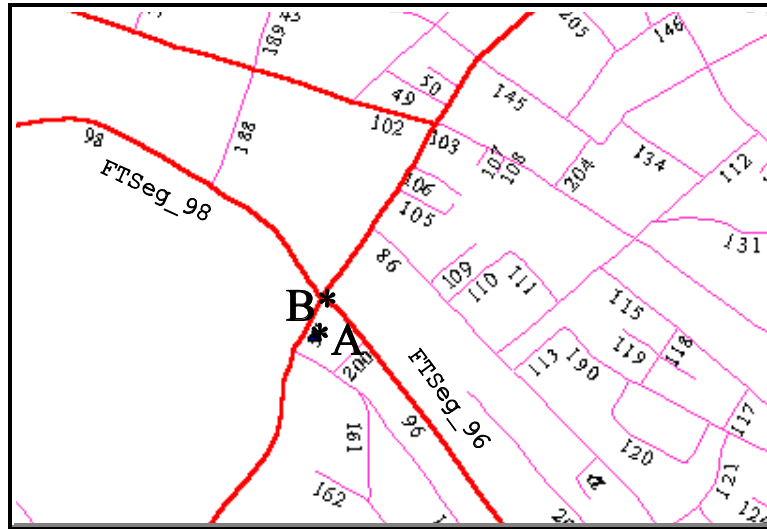37   end points for `FTSeg_98`

38   and `FTSeg_96` could be

39   improved over time:

Figure 1 – Improvements in FTRP over time

	ID	Auth.	Date	Description & Accuracy Statement	LAT.	LONG.
40						
41	A	US-DOT	1996-0101	Intersection of Vermont Route 12 and US Route 2 in Montpelier (VT); position extracted from ITS Datum Prototype,V1.1; estimated accuracy = +/-80 ft	44.25738	-72.5783
42	B	City	1998-0101	Intersection of road center lines of Vermont Route 12 and US Route 2 in Montpelier (VT); position based on 1:5000 digital Ortho photograph; estimated accuracy = +/- 11 ft.	44.25739	-72.5782

43   2   **Economical**

44   **Placement of FTRP**

45   The figure at right shows

46   the designation of an FTRP

47   (`P3`) at the intersection of a
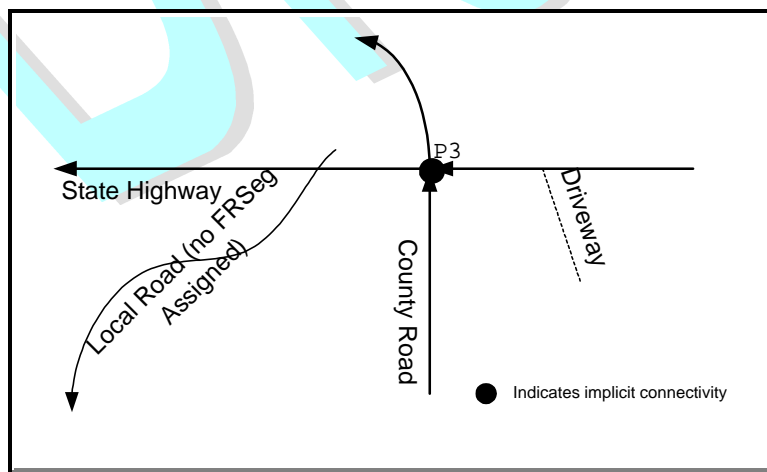
48   state highway and a county

Figure 2 Economical placement of FTRP with regard to intersections

49   road. Both physical roads are represented as FTSeg which terminate at this intersection.

50   Additional FTRP should not be introduced to mark the intersection with a driveway or

51   with a local road which is not assigned an FTSeg.

52   **3   Transportation Segments and Sub-state Jurisdictional Boundary Lines**

53   The following figure illustrates the identification of FTRP at various points in and around

54   the intersection of roads with a sub-state boundary. A road runs from point "A" to point

55   "C", running along several

56   township or county

57   boundaries, passing through

58   the shared corner of four

59   jurisdictions, and taking a
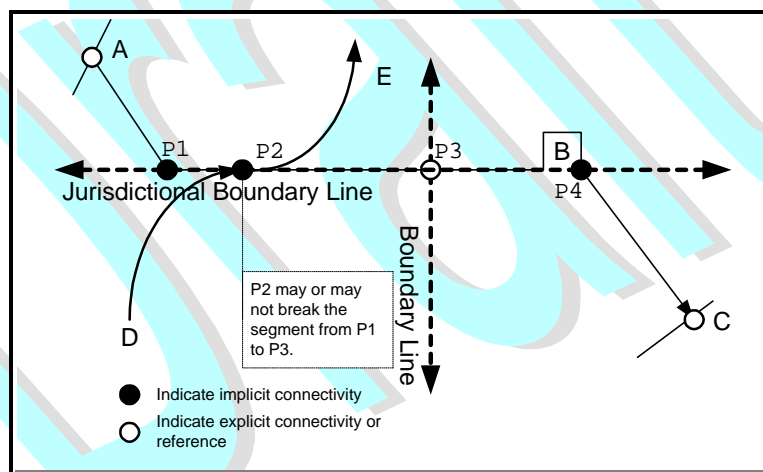
60   short departure from the

61   boundary around point "B".

62   In this example the

Figure 3 Roads on or crossing County Boundaries

63   transportation segments terminate at points "A" and "C," and these FTRP implicitly

64   connect these segments to other segments not illustrated. Further, FTRP "P1" and "P4"

65   would be used to implicitly connect segments at the points where the road leaves the

66   county boundary. "P3" would be a FTRP which terminates segments at the point where

67   the road crosses from a boundary line which separates two jurisdictions to a boundary line

68   which separates a different pair of jurisdictions. Additional FTRP would be identified

69   around point "B" only if transportation authorities determine that it is made up of

70   significant segments.

71   Additionally, a FTRP could (optionally) be defined at"P2" – the point where road "D-E"

72   intersects the jurisdictional boundary. Point "P2" would implicitly connect segments of

73   road "D-E" but need not break the FTSeg between P1 and P3. P2 would break this

74   segment only if transportation authorities determined that creation of two FTSeg between

75   P1 and P3 would be helpful for data sharing.

76   **4   Road (Re)Construction**

77   The "Old Road" `FTSeg_1` ran from point "P1" to the intersection at reference point

78   "P2," where it implicitly connected with `FTSeg_3` and `FTSeg_4`. It has been replaced

79   by a reconstructed

80   `FTSeg_2`, which

81   terminates at the new "P3."

82   P2 and P3 may be at

83   nearby locations; but P2

84   must be retained as a
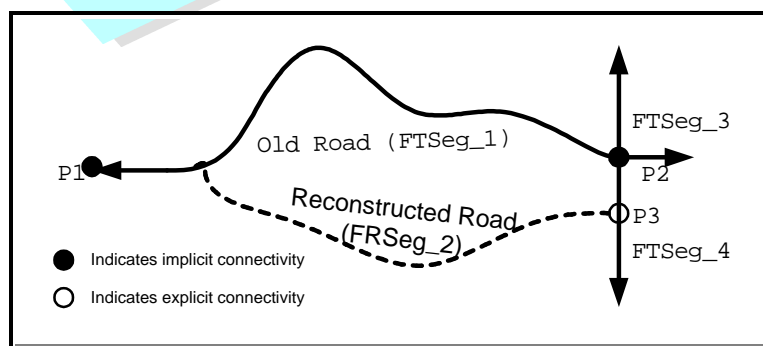

Figure 4 Road Reconstruction

85   terminus of `FTSeg_3` and `FTSeg_4`,   as well as the unnamed segment which runs to

86   the right edge of the figure. P3 must be created in order to reflect the creation of

87   `FTSeg_2`, and is explicitly connected to `FTSeg_4` at some offset along its length. The

88   following records need to be created, updated and retired:

	Segment / Point ID	Action	Description
Action 1	FTSeg_1	Retire	Old road is discontinued
Action 2	FTSeg_2	Create	New road is constructed
Action 3	P2	Update	Modify description to reflect retirement of FTSeg_1
Action 4	P3	Create	Create new record reflecting reconstructed reference point of FTSeg_2

89
90
91
92

93   **5   Integration of Physical and Logical FTRP and FTSeg at a Complex Intersection**

94   The figure below illustrates the FTSeg and FTRP which might be used to represent a

95   complex intersection of divided roadways. Red objects (heavy lines) illustrate how the
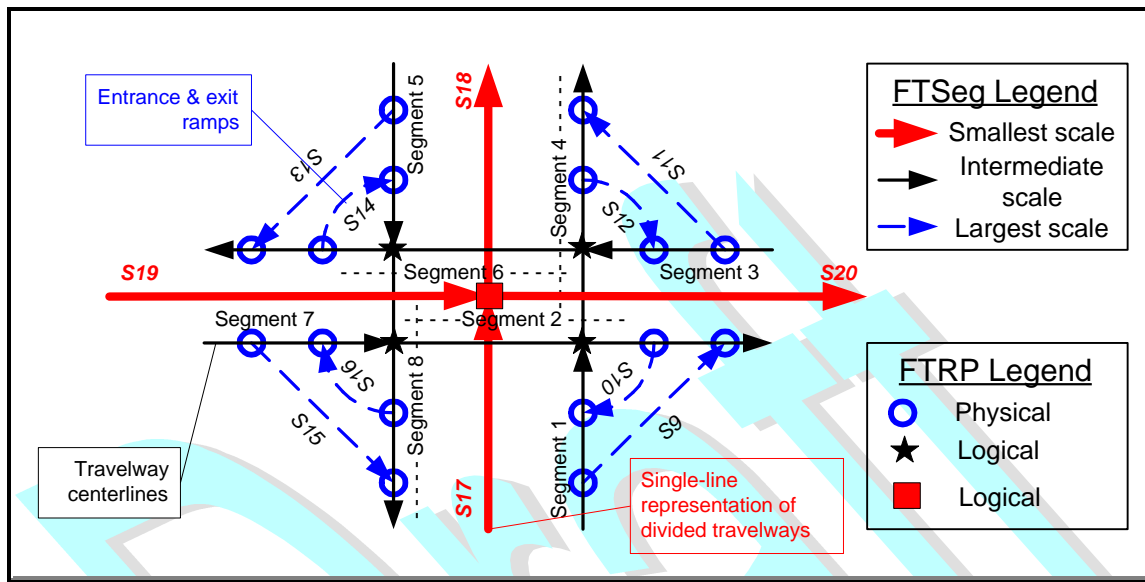

Figure 5 - A Complex Intersection

96   intersection might be represented in a small-scale spatial database (e.g. those based on

97   TIGER files). Black objects (normal lines) illustrate how the same intersection might be

98   represented in a spatial database for which 1:24,000 topographic maps provided the

99   source materials. Blue objects (dashed lines) illustrate the FTSeg and FTRP which would

100   be necessary to represent segments for each exit and entrance ramp in a large-scale spatial

101   database (e.g., those developed from source materials scaled at 1:12,000 or larger). Users

102   of the red, blue, and black objects must be able to relate information contained in one

103   database to the segments and points represented in the other database(s).

104   **6   Creation of a new FTRP**

105   New FTRP should be identified and created only when an existing FTRP cannot be

106   utilized because it is not of the correct **Category**, or because the **Location-Description**

107   and **Horizontal-Accuracy-Description** code do not indicate that the desired point is

108   located appropriately, or with the degree of accuracy desired by the data developer.

109   *Example: An existing "logical" FTRP is described as being located "at the intersection*

110   *of centerlines" of an elevated crossing, and coded as being based on 1:100,000 scale*

111   *source maps. A developer of a local E-911 transportation database requires greater*

112   *precision for a "physical" FTRP, so creation of a new record is needed.*

113   6.1   Existing FTRP: Same Category: Unhelpful (estimated) Accuracy

114   The figure below illustrates a situation in which a developer of "intermediate scale"

115   transportation data identifies

116   the pre-existing "logical"

117   FTRP shown as LP-1. This

118   FTRP has a **Horizontal-**

119   **Accuracy-Description** code

120   which leads the developer to

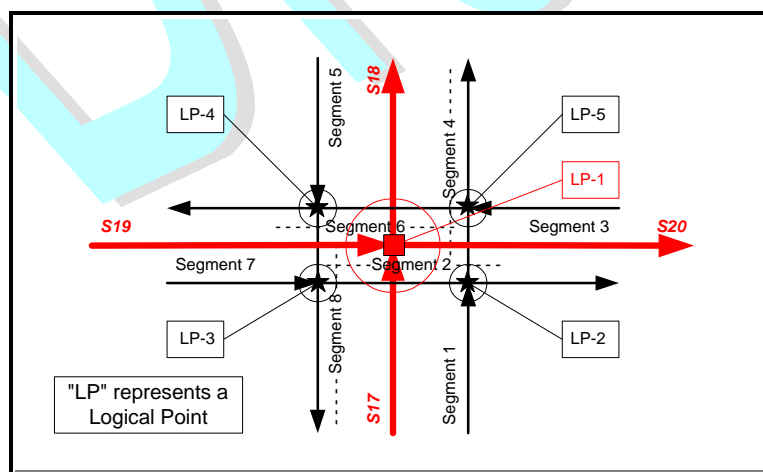121   estimate its location as

Figure 6 - Illustration of a pre-existing "Logical" FTRP
insufficiently accurate for "intermediate scale" reference

122   anywhere within the red circle around LP-1.

123   The developer must create new LP-2 through LP-5 in order to terminate FRSeg-1 through

124   FRSeg-8, and to allow accurate depiction of connectivity along these segments. The

125   black circles around each of these FTRP indicate the locational accuracy which the data

126   developer is able to assign to these points.

127   The developer should also create four entries in the FTRP Identity Table to document the

128   logical identity between LP-2 through LP-5, and LP-1. (See following Section.) **A new**

129   **FTRP is created, and requires entries in the FTRP Identity Table.**

130   6.2   Existing FTRP: Same Category: Useful (estimated) Accuracy

131   The sequence of events is reversed in the figure below. That is, the developer of "small

132   scale" data discovers the pre-existence of FTRP (LP-1 through LP-4) useful for "medium

133   scale" database

134   representation. The "small

135   scale" developer believes

136   each of these FTRP to be

137   positioned with an accuracy

138   represented by the circle

139   around LP-1. This is a point

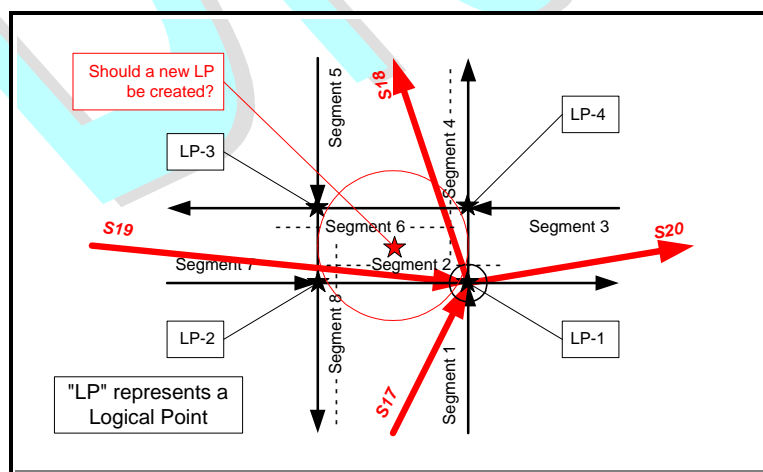140   whose accuracy description

Figure 7 - Illustration of a pre-existing "Logical" FTRP useful for "small scale" reference

141   meets the less-exacting locational accuracy requirements inherent in the "small scale"

142   database.

143   Therefore, rather than creating a new FTRP (represented by the red star at the center of

144   the intersection) the data developer utilizes the existing LP-1. **An existing FTRP is**

145   **utilized, and no new entries in the FTRP Identity Table are required.**

146   The previous examples are illustrated with "logical" FTRP, but the same reasoning

147   should be applied if existing "physical" FTRP can be considered for utilization in creating

148   new FTSeg.

149   6.3   Existing FTRP: Different Category: Unhelpful (estimated) Accuracy

150   The developer of "small

151   scale" data (represented by

152   segments S17 through S20)

153   discovers the pre-existence

154   of FTRP (PP-1 through PP-

155   4) developed by local

156   government to terminate

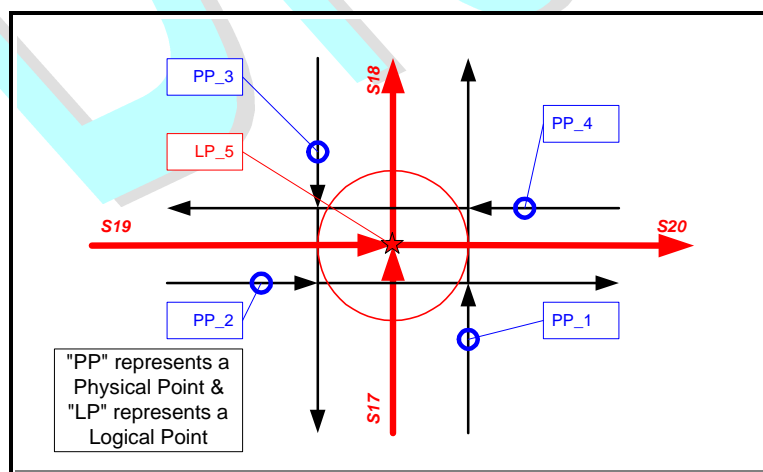157   "large scale" segments

Figure 8 - Illustration of pre-existing "Physical" FTRP not useful for "large scale" reference

158   representing entrance and exit ramps. The developer needs a "logical" FTRP to terminate

159   segments S17 through S20, and it can be located with relatively unexacting accuracy

160   represented by the circle around LP-1. However the existing "physical" FTRP have been

161   located with high accuracy, and fall outside of the tolerance allowed by the developer.

162   The developer must create new LP-5 in order to terminate S17 through S20, and to allow

163   accurate depiction of connectivity along these segments. The developer should also create

164   four entries in the FTRP Identity Table to document the logical identity between PP-1

165   through PP-4, and LP-1.

166   6.4   Existing FTRP: Different Category: Useful (estimated) Accuracy

167   The developer of "medium

168   scale" data finds pre-

169   existing "physical" FTRP

170   developed by local

171   government to terminate

172   "large scale" segments

173   representing entrance and

174   exit ramps.   The "medium

175   scale" developer wishes to

Figure 9 - Illustration of a pre-existing "Physical" FTRP useful for "intermediate scale" reference

176   use FTRP with an estimated accuracy represented by the circle around LP-1. The

177   "physical" FTRP fall within this range. Therefore, rather than creating a new FTRP

178   (represented by the stars at the four intersections) the data developer utilizes four of the

179   existing "physical" FTRP. **Existing FTRP are utilized, and no new entries in the**

180   **FTRP Identity Table are required.**

1   Appendix E

2   **Open Issues**

3   (Informative)

4   The following are intended for the discussion of the Technical Review Committee. Each

5   issue is stated as a question (to which, of course, more than one answer can be offered.)

6   It is followed by a brief discussion of the answer(s) reflected in this draft, and of related

7   issues.

8   1   The draft standard includes limited topology. Specifically: 1) Connectivity at shared

9   FTRP is stipulated as "implicit connectivity," and 2) connectivity at other junctions

10   is created through entries in the FTRP record ("explicit connectivity.") What would

11   be sacrificed if the standard did not contain any topology at all? Would simplicity

12   and understandability result? This issue has been addressed by several thoughtful

13   comments (Olmstead and Deuker) on ROAD-L.

14   2   Should the "Feature_type" be embedded in the unique ID of each FTSeg and/or

15   FTRP?   Several commenters have taken the position that it is just an attribute of any

16   feature, and that such "intelligence" should not be built into the identifier?

17   3   Should the sequential/random portion of the FTRP and FTSeg unique identifiers be

18   limited to numeric characters, as is currently proposed? Are there data processing

19   efficiencies or other benefits which can be envisioned as a result of this limitation?

20   On the other hand, many users will have "legacy" alpha-numeric ID schemes for

21   segments and points, and they'll want to use these to "initialize" IDs. Do the

22   potential benefits of limiting the IDs to be numeric characters warrant the

23   disadvantaging of users with pre-existing alpha-numeric ID schemes?

24   4   Is explicit allocation of identifier number ranges for the sequential/random portion

25   of the external identifier <u>necessary</u> to the orderly assignment of these identifiers by

26   multiple transportation authorities? Or is it at least in some way desirable (See

27   Butler posting to ROAD-L)?

28   5   One authority might create "logical" FTRP and FTSeg to identify his/her single-line

29   representation of a divided highway. Another authority might create different

30   "physical" FTRP and FTSeg to identify his/her dual-line representation of the same

31   divided highway. Does the authority which acted later in time have the obligation to

32   make entries to an identify table in order to support data sharing and to help assure

33   that future users are aware of both sets of database records? If not, does anyone have

34   such an obligation? If not, what solution will support data sharing?

35   6   Authorities who define FTRP and FTSeg for complex intersections will face choices

36   of whether to represent connectivity through MORE "physical" features

37   (representing each physical segment of connectivity) or LESS "logical" features.

38   Should the Standard or the Implementation Guidelines include a recommendation on

39   how to make these choices, based on scale, or on any other criteria?

40   7   Al Butler named a "compound feature" which he called a "traversal segment," which

41   is defined as being made up of some number – not necessarily an integer – of FTSeg

42   greater than "0," but not equal to "1." He pointed out that most attributes of interest

43   to users will be associated with a "traversal segment" rather than with an FTSeg.

44   However, for purposes of data exchange, the attribute values will be associated with

45   one or more instances of an FTSeg (either complete or partial.) Should this point

46   receive greater emphasis in the standard?

47   8   There was consideration of creating a "Logical-only" flag for FTSeg which begin

48   and end at logical FTRP. Because FTSeg can be coded "physical" only when both

49   terminal FTRP are coded "physical," such a flag would separate the "Logical-only"

50   FTSeg from those which begin or end at a "physical" FTRP. Would the use of such

51   a flag offer benefits that would outweigh the cost of accurately maintaining another

52   FTSeg attribute?